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AN

INTRODUCTION TO THE USE of the GLOBES, AND THE ORRERY:

ALSO,

The Application of Aſtronomy to Chronology;

In which are contained

RULES and MEMORIAL CANONS for finding the *Dominical Letter*, *Leap-Year*, *Epact*, *Eaſter*, &c. according to the Gregorian Account or New Style; with an Explication of the Reaſon of each Rule.

Adapted to

The INSTRUCTION and ENTERTAINMENT of ſuch Perſons as are not previouſly verſed in Mathematic Science.

WITH AN

APPENDIX,

Attempting to explain the Account of the Firſt and Fourth Days Work of CREATION in the Firſt Chapter of *Geneſis*.

By DAVID JENNINGS, *D. D.*

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THE PREFACE.

THE Perſons for whoſe Sake and Uſe the following Treatiſe was at firſt drawn up, (or rather I ſhould ſay, as to the greater Part of it, this Collection made out of many other and larger Books) are chiefly ſuch, who, though they have not the Opportunity of attending to the more abſtruſe Parts of Mathematic Science, are deſirous at leaſt, of ſome general Knowledge in theſe Matters; ſuch who, though Providence has marked out their Tract of Life amidſt Scenes of worldly Buſineſs, yet have Souls large enough to extend themſelves, now and then, beyond this little Planet, and take a diſtant View of more remote Worlds; in the Contemplation of which, both the philoſophic and pious Mind may find Entertainment and Profit. *The Works of the Lord are great,*

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ſought out of all them that have Pleaſure therein.

I have endeavoured to keep my Readers of this ſort every where in View; and I hope nothing will be found here above their Reach; except, perhaps, in the Ninth and Tenth Chapters of the Second Part; where, indeed, they are ſuppoſed to have a little previous Knowledge of the Doctrine of Angles: But ſo little, and ſo preſently to be attained, that it need hardly be mentioned as an Exception to my general Deſign.

The Method in which I have handled the Doctrine and Uſe of the Globes, in the firſt Part, is ſomewhat ſingular. For moſt, if not all, Writers on that Subject, have treated on both Globes, as preparatory even to learning Geography; whereby, in my opinion, they have made the Threſhold to that Science, much higher than it need be. I ſee no Occaſion to perplex a young Mind with *Right* and *Oblique Aſcenſion*, *Deſcenſion*, *Aſcenſional Difference*, and many other puzzling Matters, which have no Relation to Geography, before he can be led into an Acquaintance with Lands and Seas, Kingdoms and Provinces. I have, therefore, in the firſt Place, explained the Terreſtrial Globe only, as if there were no ſuch Thing

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Thing as a Celeſtial one; after which I would propoſe that the young Student ſhould read ſome Syſtem of Geography, before he proceeds to the Celeſtial Globe.

For the Uſe of the Globes, I have given only Twenty Problems, out of the Multitude that are to be found in almoſt every Book on that Subject: But I conceive theſe Twenty are ſo far ſufficient, that if a Perſon is Maſter of them, he will be able readily to work any that he meets with elſewhere. The beſt Collection of this Sort, that I know of, is in Dr. *Watts's Knowledge of the Heavens and Earth made eaſy*; to which, therefore, I would refer the Learner, for his further Practice and Entertainment.

A good deal of the Second Part is adapted to *the Uſe of the Orrery*, for which Purpoſe it was drawn up; and, perhaps, an Inſtrument of that Sort may be needful to illuſtrate ſome of the Chapters, and to render them eaſily intelligible, to the Perſons whoſe Inſtruction is here chiefly aimed at. However I would propoſe the following cheap and eaſy Contrivances to thoſe who are not furniſhed with that noble Inſtrument; which may ſerve tolerably well inſtead of it.

To help the Imagination to conceive of the double Motion of the Earth, *viz.* its annual Motion round the Sun, and its diurnal Motion on its own Axis. Take a round Ball, or Globe, of an Inch or more Diameter, made of Ivory, or ſome other pretty heavy Subſtance, to repreſent the Earth; let it be painted half black, and half White; fix a Hook, or little Staple, any where in the Circle that divides the Black from the White Hemiſphere; tie a String to it, of two Feet, or more, in Length; twiſt the String, ſo that when it is let go, and the Ball ſuſpended by it, it will untwiſt, and thereby turn the Ball ſwiftly round; then holding the End of the String directly over a Candle (to repreſent the Sun) ſo that the Ball may hang as low as the Flame of the Candle, give it a circular Motion round the Candle, to repreſent that of the Earth round the Sun; and the untwiſting of the String will, at the ſame Time, give it one round its Axis, repreſenting the diurnal Motion of the Earth. The Uſe of painting the Globe Black and White, in this Experiment, is to make the diurnal Motion viſible, which otherwiſe, when the Ball moves ſwiftly round, would hardly be ſeen.

Again, to help the Imagination to conceive, how the annual Motion of the Earth occaſions the lengthening and ſhortening of Days, and the Change of Seaſons. Take another Ball, or Globe, of about two, or three, Inches Diameter; let it be painted all over White; only let the Poles be marked upon it, and the Equator, Tropics, and Polar Circles, be drawn with Black; make a Spot alſo to mark the Latitude of any given Place, (ſuppoſe *London*;) let a Hole be bored through the Globe from Pole to Pole, into which put a Spindle, or Axis, on which it may turn round. Then ſetting a Candle directly before you, on a Table, in a darkened Room, hold the Axis of the Globe, (which muſt, therefore, be longer than its Diameter, in order to your holding the Globe upon it,) not perpendicular to the Table, but inclined to it in an Angle, as near as you can gueſs, of 66½ Degrees; and let the Globe be held as high from the Table as the Flame of the Candle. Firſt, hold the Globe with its North Pole from you, at a Diſtance from the Candle, on the left Hand of it; ſo that the Circle of Illumination may paſs through both Poles: It then repreſents the Poſition and Place of the Earth at the *Vernal Equinox*. Move the Globe towards you, in a Circle parallel to the Table, obſerving to keep the Axis in the ſame Inclination, and always parallel to itſelf, or pointing the ſame Way; when the Globe is brought directly betwixt you and the Candle, it repreſents the Poſition and Place of the Earth at the *Summer Solſtice*; and, if the Axis of the Globe is duly

inclined

inclined to the Table, the enlightened Hemiſphere will juſt take in the whole Northern Frigid Zone. Carry on the Globe to the right Hand of the Candle, directly oppoſite to the Place where you held it at firſt, and it will repreſent the *Autumnal Equinox*; when it is moved to be directly beyond the Candle, it repreſents the *Winter Solſtice*. And, by turning the Globe on its Axis, in ſeveral Parts of the Circle, in which it is moved round the Candle, you will ſee how the Days lengthen and ſhorten in that Place whoſe Latitude is marked upon it. Perhaps it may be of ſome Uſe to draw a Circle with Chalk, upon the Table, round the Candle, as its Center, over which you are to move the Globe. Or a Circle made of Wood, Paſtboard, or Paper, divided and marked with the twelve Signs of the Zodiac, and laid upon the Table, may ſtill do better.

By Means of this Globe, and the other Black and White one, now ſuppoſed to repreſent the Moon, (which ſhould therefore be made leſs than the Earth,) the Phaſes of the Moon may be ſhewed in the ſeveral Parts of her Orbit round the Earth. Let the white Hemiſphere repreſent that Hemiſphere, and Face of the Moon, which is always obverted to the Earth; and the Light of the Candle will ſhew how much of it is enlightened, by the Sun, in every Part of her Orbit.

Again, by means of theſe two Globes, the Doctrine of Eclipſes, and of the Tides, may be tolerably well illuſtrated.

And if the leſſer Globe be carried round the Candle, either further off than the Earth, to repreſent a ſuperior Planet; or nearer, to repreſent an inferior one; it may eaſily be ſhewed, how the Planets will ſometimes appear Weſtward of the Sun, ſometimes Eaſtward; and, conſequently, how they are ſometimes Morning Stars, ſometimes Evening Stars to the Earth.

In the Third Part of the enſuing Treatiſe, which ſhews the Application of Aſtronomy to Chronology, I have inſerted ſeveral memorial Canons, adapted to the Gregorian Style, for moſt of which I am obliged to Mr. *John Canton*, M. A. and F. R. S. all thoſe, and the Explications of them, which are marked with an Aſteriſm are His.

The Hypotheſis in the Appendix is, for ought I know, entirely new. I offer it as an Hypotheſis. It is ſatisfactory to my own Mind; whether it will appear ſo to others, I muſt leave with my readers.

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An

An EXPLICATION *of ſome* Algebraic, *and other Characters, uſed in this* BOOK.

$=$ IS the Sign of Equality, and is read *equal*, as 3 and $2=5$, ſignifies 3 and 2 are equal to 5.

$+$ Is the Sign of Addition, and is read *plus*, or *more*, as $4+2$, ſignifies 4 more 2, or 2 added to 4, $=6$.

$-$ Is the Sign of Subſtraction, and is read *minus*, or *leſs*, as $9-2$, Sgnifies 9 leſs 2, or 2 ſubſtracted from 9, $=7$.

$\times$ Is the Sign of Multiplication, as 4×3 ſignifies 4 multiplied by 3, $=12$.

$\div$ Is the Sign of Diviſion, as $12\div 3$ ſignifies 12 divided by 3, $=4$.

Degrees are ſometimes expreſſed by a little Circle over the right Hand Corner of a Figure, as 5° ſtands for 5 Degrees.

Minutes, by a ſingle Stroke, as $5'$ ſtands for 5 Minutes.

Seconds, by 2 Strokes, as $5''$ ſtands for 5 Seconds.

THE

PART I.

The Doctrine and Uſe of the GLOBES.

CHAPTER I.

A Deſcription of the Globes; particularly of the Terreſtrial Globe, its Points and Circles.

A GLOBE or Sphere ſignifies a round Body, every Part of whoſe Surface is equally diſtant from its Center.

By THE GLOBES, which we are now to treat of, we mean two ſuch artificial ſpherical Bodies, one of which is ſuppoſed to repreſent the Earth, and the other the viſible Heavens. The former is called the *Terreſtrial* or *Terraqueous* Globe, the latter the *Celeſtial.*

Half a Globe or Sphere is called a *Hemiſphere.*

The Terreſtrial Globe is an artificial Repreſentation of the natural Earth, having the whole Surface of the Land and Sea drawn upon it, in their natural Form, Order, and Situation.

The Spindle on which the Globe turns is called its *Axis* *; which in the artificial Globe is real, in the natural only imaginary.

The two extreme Points of the Earth's Axis are called its *Poles*, viz. the North, called the *Arctic*; and the South, called the *Antarctic*.

The Earth is ſuppoſed to be ſurrounded with ſeveral imaginary Circles, which are either drawn upon the artificial Globe, or expreſſed by the Wooden and Braſs Work about it.

Theſe Circles are diſtinguiſhed into *Greater*, and *Leſſer*. The *greater* Circles divide the Globe into two equal Parts, the leſſer into unequal.

Of the Greater Circles, viz. *the* Horizon, *the* Equator, Meridians, *and the* Ecliptic.

I. The HORIZON, which is expreſſed by

---

* The Reader who deſires to know the *derivation* of the terms of Art made uſe of in this Treatiſe, is referred to larger ſyſtems, particularly *Gordon*'s Geographical Grammar, P. 1. § 1.—*Hubner*'s Introduction to Geography, C. 1. — 6.

the upper Surface of the wooden Circle in which the Globe ſtands, divides the Globe into an upper and lower Hemiſphere. This is called the *Rational Horizon*, to diſtinguiſh it from the *ſenſible* or *apparent Horizon*, which bounds our Proſpect all round us, and which is greater or leſs, according as we ſtand higher or lower. For Example, an Eye placed at five Feet above the Surface of the Earth or Sea, ſees two Miles and three Quarters every way: but if it be at twenty Feet high, it ſees five Miles and an half.

The Riſing and Setting of the Sun and Stars properly reſpects the Rational Horizon; that is, they riſe when they get above it, and ſet when they ſink below it: But, by reaſon of their vaſt Diſtance from us, the Rational and ſenſible Horizon are to be conſidered, in this Caſe, as one and the ſame.

The wooden Horizon of the Globe has ſeveral Circles drawn upon it. The outermoſt is marked with the Points of the Mariners Compaſs; of which the *Eaſt*, *Weſt*, *North*, and *South*, are called the *Cardinal Points*, dividing the Horizon into four Quarters. Each of theſe Quarters is ſubdivided into eight Points, in all thirty-two, called *Rumbs*; and Lines drawn from any Point upon the Surface of the Globe towards the ſeveral Rumbs, are called

Rumb Lines. The other Circles upon the Horizon will be conſidered afterwards.

II. The EQUATOR divides the Globe into the Northern and Southern Hemiſpheres. This is what Sailors call *The Line*; and when they paſs over it at Sea, they are ſaid to *croſs the Line*. From this Line the Degrees of *Latitude* are counted towards the Poles, *viz.* 90 towards each Pole *.

III. Semicircles reaching from Pole to Pole, and cutting the Equator at right Angles, are called MERIDIANS. 360 ſuch Semicircles, drawn at equal Diſtances, quite round the Globe, mark the Degrees of *Longitude*, which are numbered upon the Equator, and are counted from the firſt Meridian.

The Meridian which paſſes through *Fero*, one of the *Canary* Iſlands, is generally made the firſt Meridian upon the Terreſtrial Globe.

---

* Every Circle, whether great or ſmall, is ſuppoſed to be divided into 360 equal Parts called Degrees. Two Lines drawn from any two Points in the Circumference of a Circle to the Center (except two Points that lie in a ſtrait *Fig.* 1. Line with the Center, as A and E) form an Angle at the Center which is called an Angle of ſo many Degrees, as are contained in the Arch of the Circle betwixt the two Points. Thus an Angle of 90 Degrees, or right Angle, is meaſured by ¼ of the Circle; an Angle of 45° by ⅛. ACB is an Angle of 96°, BCD 45° ACD 135°. *N. B.* A Degree is divided into 60 Minutes, a Minute into 60 Seconds, a Second into 60 Thirds, &c.

So much as any Angle, or Arch of a Circle, wants of 90 Degrees, is called the *Compliment* of that Angle or Arch; as D E is the Compliment of the Arch B D, and of the Angle B C D.

But different Nations fix the firſt Meridian in different Places: Some *Engliſh* Geographers and Map-makers, make that to be the firſt Meridian which paſſes thro' *London*. And the *Longitude* is counted from it, Eaſt and Weſt.

Two of theſe Semicircles joined together, ſo as to compleat the Circle, are called *Whole Meridians*. Such a one is expreſſed by the brazen Circle in which the Globe turns, and by which it is divided into the Eaſtern and Weſtern Hemiſpheres. The graduated Edge of this Meridian repreſents the Meridian of any Place, when, by turning the Globe, the Place is brought juſt under it.

Meridians at fifteen Degrees diſtance from each other are called *Hour-circles*; becauſe the Places that each of them paſs through have Noon an Hour earlier than at fifteen Degrees more Weſtward, and later than at fifteen Degrees more Eaſtward. Hence the *Longitude* is often expreſſed by *Hours*, as *Long. W. of London* 4h 17m for 64° 15′ *Weſt of London*.

N. B. The Horizon and Meridians are called *changeable Circles*; becauſe by changing our Place, Eaſtward or Weſtward, we change our Meridian; ſince the Meridian of any Place is a Circle paſſing, North and

South,

South, directly over it. And by removing towards any Point of the Compaſs we change our Horizon, both ſenſible and Rational; ſince both the Proſpect all around us, and the Hemiſphere which we ſtand in the Middle of, are now bounded by different Circles than they were before.

The Changeableneſs of theſe Circles is repreſented by the Globes being made to move within them; by which Means any Place can be brought under its proper Meridian; and into the Middle of the Hemiſphere which is bounded with its proper Horizon.

IV. The ECLIPTIC cuts the Equator obliquely in two oppoſite Points, making with it an Angle of twenty-three Degrees and an half. This is that Circle round the Earth, which anſwers to the Sun's apparent annual Path in the Heavens: or it is ſuch a Circle on which if you ſuppoſe a Man to travel round the World in the Space of a Year, keeping pace with the Sun's apparent annual Motion, *i. e.* about ſixty-ſeven Miles a Day, and ſuppoſe he has the Sun *vertical*, or directly over his Head, the firſt day at Noon, he will have the Sun directly over his Head every day at Noon throughout the Year.

This Circle is divided into twelve times 30 Degrees, in all 360. Theſe twelve Portions of the Ecliptic are called by twelve different Names, *viz.*

1. ♈ Aries, *the Ram.* 2. ♉ Taurus, *the Bull.* 3. ♊ Gemini, *the Twins.* 4. ♋ Cancer, *the Crab.* 5. ♌ Leo, *the Lion.* 6. ♍ Virgo, *the Virgin.* 7. ♎ Libra, *the Ballance.* 8. * ♏ Scorpio, *the Scorpion.* 9. ♐ Sagittarius, *the Archer.* 10. ♑ Capricornus, *the Goat.* 11. ♒ Aquarius, *the Waterer.* 12. ♓ Piſces, *the Fiſhes* *. * ♏ Scorp

Theſe Names refer to the Stars, among which the Sun ſeems to paſs in his annual Circuit round the Earth. Theſe are called the twelve Signs of the Zodiac †. If we would know to what Part of the Ecliptic the Sun is vertical any time of the Year, we may learn it from the four innermoſt Circles upon the wooden Horizon.

On the firſt, or innermoſt, are marked the Degrees of the twelve Signs.

The ſecond has the Names, Characters, and Figures of thoſe Signs.

The third is a Calendar of Months and Days, according to the New Style, anſwering to the Degrees of the twelve Signs; by which is ſeen what Sign and Degree the Sun is in every Day throughout the Year.

---

* The Reader may ſee a memorial Stanza for the Twelve Signs and their Order in Dr. *Watts*'s Aſtronomy, P. 9. or a ſingle Latin Diſtich in the *Gradus ad Parnaſſum*, on the word Zodiacus.

† Concerning the Invention of thus dividing the Zodiac, the Reader may, perhaps, be pleaſed with conſulting the *Sequel to the* 4th *Vol. of Nature diſplayed*, Dialogue I.

The fourth is a Kalendar, in the ſame manner, according to the Old Style.

N. B. Points at 90 Degrees diſtant from any greater Circle, are called the Poles of that Circle. But when we ſpeak of THE POLES, without mentioning the Circle to which they relate, we always mean the Poles of the Equator, which are the Extremities of the Axis of the Earth's diurnal Rotation. Theſe are alſo called the Poles of the World.

Suppoſe the Earth were cut in half at any greater Circle, it would produce a Plane, which is called the Plane of that Circle; as the *Plane of the Equator*; the *Plane of the Meridian*, &c.

A Map repreſenting the Surface of half the Globe, is ſaid to be projected upon the Plane of the Meridian, when the Pole of the Meridian is in its Center; and the Poles of the Equator are in the Periphery or Circumference. A Map projected upon the Plane of the Equator, has the Pole of the World in its Center. A Map projected upon the Plane of the Horizon of *London*, has *London* in the Middle of it.

N. B. Maps of the World are generally projected upon the Plane of the Meridian; but Maps of the Stars upon the Plane of the Equator, or of the Ecliptic.

Of the Leſſer Circles, viz. the Tropics, *the* Polar Circles, Parallels of Latitude, *and the* Horary Circle.

I. The TROPICS are two leſſer Circles, each at 23½ Degrees diſtance from the Equator, to which they are parallel or equidiſtant in all Parts. That on the North of the Equator is called the *Tropic of Cancer*, to which the Sun is vertical at the Summer Solſtice, or longeſt Day of the Year to the Northern Hemiſphere. That on the South is the *Tropic of Capricorn*, to which the Sun is vertical at our winter Solſtice, which is the longeſt Day of the Year to the Southern Hemiſphere.

II. The two POLAR CIRCLES are parallel to the Tropics, each at 23½ Degrees diſtance from the Pole. The Northern is called the *Arctic Circle*, the Southern the *Antarctic*.

N. B. A Globe which does not conſiſt of one continued Surface, but only of the greater and leſſer Circles, made of Braſs, Wood, Paſteboard, *&c.* and put together in their natural order, is called an *Armillary Sphere*.

Other Circles drawn parallel to the Equator are called PARALLELS of LATITUDE: 90, or rather 89, ſuch Circles drawn at equal Diſtances betwixt the Equator and the Pole, mark the Degrees of *Latitude*, which are number'd on the graduated Edge of the Brazen Meridian.

The *Parallels of Latitude* and *Meridians* are the Lines which are drawn upon Maps, croſſing one another, and marking the Degrees of *Latitude* and *Longitude*.

III. The Braſs Circle with an Index faſten'd at the North Pole of the Globe, is called the HORARY CIRCLE; it is divided into twice 12 Hours, anſwering to the Time in which the Earth performs its diurnal Revolution: The upper 12 is for 12 at Noon, the lower for 12 at Night.

CHAP. II.

Of the Diviſions of the Earth.

THE whole Surface of the terraqueous Globe admits of ſeveral different Diviſions; as

FIRST, By the various Poſitions of the Globe in reſpect to the *Horizon*.

1. Where the Poles of the Horizon are in the Equator, it is called a *Right Sphere*;

becauſe then the Equator, and all its Parallels, cut the Horizon at right Angles. There the Poles of the World are in the Horizon; all the Stars riſe and ſet, and the Days and Nights are always equal.

2. Where the Poles of the World are the Poles of the Horizon, it is called a *Parallel Sphere*; the Equator, and all its Parallels, being then parallel to the Horizon. There the Sun, Moon, and Stars, appear to move round in Circles parallel to the Horizon; the ſame Hemiſphere of fixed Stars is always above the Horizon; and there is but one Day and one Night in a Year, each of ſix Months.

3. When the Poles of the Horizon are any where betwixt the Equator and the Poles of the World, it is called an *Oblique Sphere*; the Equator, and its Parallels, there croſſing the Horizon obliquely. There ſome Stars never ſet, others never riſe; the Days and Nights are of different Lengths in different Seaſons of the Year; and there one Pole of the World only is ſeen, which is elevated, more or leſs, according to the Obliquity of the Sphere. For the *Elevation of the Pole*, in any Place, is the Height of it above the Horizon, meaſured by Degrees on the Meridian; and it is always equal to the Latitude of the Place: So that the Pole being duly elevated for any Place, and the Place brought under the graduated

Edge of the brazen Meridian, it is exactly in the Pole of the Horizon.

Secondly, The Diviſion of the Earth into *Zones.*

The Tropics and Polar Circles divide the Globe into five *Zones*, or Belts, which have their Names from the different Degrees of Heat and Cold, which, by their Situation, they are ſubject to, *viz.* One *Torrid Zone*, two *Temperate*, and two *Frigid.* The *Torrid Zone* lies betwixt the two Tropics; the two *Temperate Zones* are comprehended betwixt the Tropics and Polar Circles; and the two *Frigid Zones* lie within the Polar Circles *.

Thirdly, The Diviſions of the Earth by the relative Situation of its Inhabitants to one another, in reſpect to Days and Seaſons.

1. Thoſe who live in the ſame Degree of Longitude, and in equal Latitudes, one North, the other South of the Equator, are called *Antæci.* The Hour of the Day and Night are the ſame with both, but the Seaſons of the Year are contrary.

2. Thoſe who live in the ſame Latitude, but in oppoſite Points of Longitude, are

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* The Ancients imagin'd the *Temperate Zones* only were habitable, ſee *Ovid* Metamorphoſ. B. I. l. 49, 50. *Virgil* Georg. B. I. l. 233—8.

called *Periæci.* Their Length of Days and Seaſons of the Year are the ſame; but their Days and Nights are contrary.

3. Thoſe who live in equal Latitudes, one North, the other South, and alſo in oppoſite Points of Longitude, are called *Antipodes.* Theſe have Days, and Nights, and the Seaſons of the Year, all contrary to one another †.

FOURTHLY, The Diviſion of the Earth by *Climates.*

Climates are bounded by Parallels of Latitude, drawn at ſuch a Diſtance from each other, as that the longeſt Day at the leſſer Parallel, exceeds that at the next greater Parallel, by half an Hour. There are twenty-four ſuch *Climates* betwixt the Equator and each Polar Circle, which grow narrower as they lie farther diſtant from the Equator. And there are reckoned ſix Climates more from each Polar Circle to its Pole, which increaſe not by half Hours, but by Months.

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† There is another old Diviſion of the Inhabitants of the Earth, with reſpect to their Shadows, *viz,* into *Aſcii, Periſcii,* &c. ſee *Gordon,* P. I. § 1.

A TA-

A TABLE of the CLIMATES.

Climates.	From the Equator to the Polar Circles				Climates	From the Equator to the Polar Circles.			
	Ends in Latitude		*Where the longeſt Day is.*			*Ends in Latitude*		*Where the longeſt Day is*	
	D	M	H	M		D	M	H	M
1	8	25	12	30	17	64	06	20	30
2	16	25	13	00	18	64	49	21	00
3	23	50	13	30	19	65	21	21	30
4	30	20	14	00	20	65	47	22	00
5	36	28	14	30	21	66	06	22	30
6	41	22	15	00	22	66	20	23	00
7	45	29	15	30	23	66	28	23	30
8	49	01	16	00	24	66	31	24	00
9	51	58	16	30		From the Polar Circles to the Poles			
10	54	27	17	00					
11	56	37	17	30	1	67	30	1	Months
12	58	29	18	00	2	69	30	2	
13	59	58	18	30	3	73	20	3	
14	61	18	19	00	4	78	20	4	
15	62	25	19	30	5	84	00	5	
16	63	22	20	00	6	90	00	6	

FIFTHLY, The natural and political Diviſions of the Earth.

By the *natural Diviſion* we mean that which Nature has made in the Surface of the Globe, as *Land* and *Water*. The Land is again divided into *Continents*, *Iſlands*, *Peninſulas*, *Iſthmus's*, *Promontories*, *Coaſts*, *&c.* The Water is alſo diſtinguiſhed into *Seas*, *Oceans*, *Lakes*, *Gulphs*, *Bays*, *Straits*, *Rivers*, *&c.*

The *political Diviſion* of the Earth is made by Men, who have diſtinguiſhed it into *four Quarters*; and theſe again into *Empires*, *Kingdoms*, *States*, *Republics*, *Principalities*, *Provinces*, *Counties*, *Pariſhes*, *&c.* For a particular Deſcription of all which we refer to *Gordon's Geographical Grammar*, or ſome larger Syſtem of Geography.

CHAP. III.

A Deſcription of the Celeſtial Globe, its Points and Circles.

THE Celeſtial Globe is an artificial Repreſentation of the Heavens, having the fixed Stars drawn upon it, in their natural Order and Situation.

It is not pretended that the Celeſtial Globe is ſo juſt a Repreſentation of the Heavens, as the Terreſtrial Globe is of the Earth; becauſe *here* the Stars are drawn upon a convex Surface, whereas they naturally appear in a concave one. But ſuppoſe the Globe was made of Glaſs, then to an Eye placed in the Center, the Stars which are drawn upon it would appear in a concave Surface, juſt as they do in the natural Heavens.

As the Terreſtrial Globe, by turning on its Axis, repreſents the real diurnal Motion of the Earth; ſo the Celeſtial Globe, by turning on its Axis, repreſents the apparent diurnal Motion of the Heavens.

The Circles and Points which are either peculiar to the Celeſtial Globe, or which have not been taken notice of in explaining the Terreſtrial, are theſe that follow:

1. The *Zodiac*, which is a Hoop, or Belt round the Heavens, of about ſixteen Degrees broad; along the middle of which runs the *Ecliptic*, or the Sun's annual Path. The *Signs of the Zodiac* are the fixed Stars that are contained in this celeſtial Belt; and which, for diſtinction ſake, are thrown into twelve *Conſtellations*, or *Aſteriſms*, and are called *Aries*, *Taurus*, &c.

2. The two *Colures* *, which are whole Meridians, one paſſing thro' the firſt Point of *Aries* and *Libra*, where the *Ecliptic* croſſes the *Equinoctial*, (the Circle that anſwers to the Equator on the Terreſtrial Globe.) The other paſſing thro' the firſt Points of Cancer and Capricorn where the *Ecliptic* touches the *Tropics*. The former is called the *Equinoctial Colure*, the latter the *Solſticial Colure*.

3. The firſt Points of Aries and Libra are called the *Equinoctial Points* †; becauſe,

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* The Name comes from Υειλος *mutilus* and ουρα *cauda*, becauſe they are often repreſented only as half Meridians, which are not completely ſeen in an *Oblique* Sphere.

† *Equinoctial*, from *æquus* equal, and *Nox* Night.

when the Sun is in either of them, the Day and Night is every where equal.

4. The firſt Points of Cancer and Capricorn are called the *Solſtical Points* *; becauſe when the Sun arrives at either of them, he ſeems to ſtand in a manner ſtill, in reſpect to his apparent motion from and towards the Equinoctial, for ſeveral Days. When he is in one Solſtical Point, he makes the longeſt Day; when in the other, the ſhorteſt, to one and the ſame Northern, or Southern Hemiſphere.

5. The Point in the Heavens juſt over our Head is called the *Zenith*; and the oppoſite Point to it, juſt under our Feet, is called the *Nadir*. Theſe two are the Poles of the Horizon.

Imaginary Circles, drawn thro' the *Zenith* and *Nadir*, and cutting the Horizon at right Angles, are called *Vertical*, or *Azimuth Circles*. Hence the Diſtance of the Sun, or a Star, from the Meridian, or South Point of the Heavens, meaſured by Degrees upon the Horizon, is called its *Azimuth*; or ſometimes the Azimuth is reckoned from any other of the cardinal Points.

The Azimuth of the Sun, or a Star, from due Eaſt or Weſt, at the Time of its Riſing or Setting, is called its *Amplitude*.

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* *Solſtical*, from *Solis ſtatio*, the Sun's Station, or ſtanding Place.

6. The Braſs *Quadrant of Altitude*, ſcrewed upon the Zenith, and laid down to the Horizon, repreſents a Quarter of a vertical Circle. It is called the *Quadrant of Altitude*, from its Uſe in taking the Altitude, or Height, of the Sun or Stars, above the Horizon, by means of the 90 Degrees marked upon it. The Sun's Height at Noon above the Horizon is called his *Meridian Altitude*; and when he reaches that Height, he is ſaid to *Culminate*.

The Diſtance of the Sun, or a Star, from the Horizon, below it, is called its *Depreſſion*.

Imaginary Circles drawn parallel to the Horizon, thro' every Degree of the vertical Circles, are called *Parallels of Altitude*, or, (by an Arabick Name) *Almicantars*.

7. *The Poles of the Ecliptic* are generally marked on the Celeſtial Globe, which fall in the Arctic and Antarctic Circles, at 23½ Degrees diſtance from the Poles of the Equinoctial.

8. Great Circles cutting the Ecliptic at right Angles, and croſſing one another at its Poles, are called *Circles of Longitude*. And if you imagine other Circles to be drawn parallel to the Ecliptic, thro' every Degree of the Circles of Longitude, they will be *Parallels of Latitude* upon the Celeſtial Globe. For *Longitude* and *Latitude*

on the Celeſtial Globe, bear juſt the ſame relation to the Ecliptic, as they do on the Terreſtrial Globe to the Equator.

Thus, as the Longitude of Places on the Earth is meaſured by Degrees upon the Equator, counting from the firſt Meridian; ſo the Longitude of the heavenly Bodies is meaſured by Degrees upon the Ecliptic, counting from the firſt Circle, or Line of Longitude, *viz.* that which paſſes thro' the firſt Point of Aries. And as Latitude on the Earth is meaſured by Degrees upon the Meridian, counting from the Equator; ſo the Latitude of the heavenly Bodies is meaſured by Degrees upon a Circle of Longitude, counting either North, or South, from the Ecliptic.

The Sun has no Latitude, being always in the Ecliptic: nor do we uſually ſpeak of his Longitude: but his Place in the Ecliptic is expreſſed by ſuch a Degree and Minute, of ſuch a Sign; as 5 Degrees of Taurus, inſtead of 35 Degrees of Longitude.

9. The Diſtance of any heavenly Body from the Equinoctial, meaſured upon the Meridian, is called its *Declination.* Therefore the Sun's Declination, North or South, at any Time, is the ſame as the Latitude of the Place on Earth, to which he is then vertical; which is never more than 23½ Degrees. Therefore, alſo, *Parallels of Declination* on the Celeſtial Globe, are the

very ſame as *Parallels of Latitude* on the Terreſtrial.

Stars may have *North Latitude*, and *South Declination*, and vice verſâ.

The ſame Thing which is called Longitude on the Terreſtrial Globe, is called *right Aſcenſion* on the Celeſtial; *viz.* the Sun, or a Star's Diſtance from the firſt Meridian, or that which paſſes thro' the firſt Point of Aries, counted on the Equinoctial.

Aſtronomers alſo ſpeak of *oblique Aſcenſion* and *Deſcenſion*; by which they mean the Diſtance of that Point of the Equinoctial from the firſt Point of Aries; which, in an oblique Sphere, riſes, or ſets, at the ſame time that the Sun, or Star, riſes, or ſets.

Aſcenſional Difference, is the Difference betwixt right and oblique Aſcenſion. The Sun's aſcenſional Difference, turned into Time, (*i. e.* reckoning one Degree to be four Minutes, and fifteen Degrees one Hour) is juſt ſo much as he riſes before, or after, ſix a Clock.

The Hemiſphere of Stars, which is viſible by Night, is continually changing, in a right or oblique Sphere, by reaſon of the Sun's apparent Motion round the Ecliptic in a Year.

When the Sun gets ſo near a Star, as that the Star is hid in his Beams, it is ſaid to ſet *Heliacally*:

Heliacally: and when after its Conjunction with the Sun, it becomes viſible again, it is ſaid to riſe *Heliacally*.

A Star that riſes, or ſets, in the Morning, when the Sun riſes, is ſaid to riſe, or ſet, *Coſmically*.

A Star which riſes, or ſets, in the Evening, when the Sun ſets, is ſaid to riſe, or ſet, *Achronically*.

CHAP. IV.

Of the Diviſions of the Heavens, and the Conſtellations.

THE Stars appearing to be of different Sizes, ſome greater, and ſome leſs, Aſtronomers have divided them into ſix *Claſſes, or Magnitudes*; and the Stars of each Magnitude are diſtinguiſhed by different Marks on the Celeſtial Globe.

They have alſo diſtinguiſhed the Stars, in reſpect to their Situation in the Heavens, into ſeveral *Conſtellations*, or *Aſteriſms*, called *Stellæ Formatæ*, to which they have given Names: to ſome the Names of Men; to others the Names of Beaſts, Birds, and ſeveral other Things, as fancy led them. The Images of thoſe Animals, and other Things,

from

from whence the Names of the Conſtellations are taken, are drawn upon the Celeſtial Globe, over the ſeveral Parcels of Stars which are called by thoſe reſpective Names *.

The Conſtellations are divided into *Northern* and *Southern*; beſides the twelve *Zodiacal Signs*, which lie in the Middle betwixt both.

In the Northern Regions the Ancients formed twenty-one Conſtellations, *viz.* *Urſa Minor*, or the little Bear; *Urſa Major*, the great Bear; *Draco*, the Dragon; *Cepheus*; *Caſſiopeia*; *Andromeda*; *Triangulum*, the Triangle; *Perſeus*, with *Meduſa*'s Head; *Auriga*; *Bootes*; *Corona Septentrionalis*, the Northern Crown; *Hercules*; *Lyra*, the Harp; *Cygnus*, the Swan; *Pegaſus*, the flying Horſe; *Equiculus*, the little Horſe's Head; *Delphinus*, the Dolphin; *Sagitta*, the Arrow; *Aquila*, the Eagle or Vultur; *Serpens*, the Serpent; and *Serpentarius*, the Man who holds it.

To theſe the Moderns have added ſeveral more, as *Antinous*, near the Eagle; *Coma Berenices*, or Berenice's Hair, near the Lion's Tail; *Leo Minor*, the little Lion, betwixt the Lion and the great Bear, &c.

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* *N. B* The letters of the *Greek* and *Latin* Alphabets, which are placed by many of the Stars on *Senex*'s Celeſtial Globe, are thoſe by which *Bayer* has marked them in his Catalogue of the Stars.

South of the Zodiac the Antients numbered fifteen Conſtellations, *viz. Cetus*, the Whale; the River *Eridanus*; *Lepus*, the Hare; *Orion*, which is the moſt glorious Conſtellation of all; *Canis Major*, the great Dog; *Canicula*, the little Dog; *Argo Navis*, The Ship Argo; *Hydra*; *Crater*, the Cup; *Corvus*, the Crow; *Centaurus*, the Centaur; *Lupus*, the Wolf; *Corona Auſtralis*, the Southern Crown; *Ara*, the Altar; and *Piſcis Auſtralis*, the Southern Fiſh.

To theſe the Moderns have added twelve Conſtellations more, which lie ſo near the South Pole, that they cannot be ſeen in our Northern Latitude.

There are ſtill ſome Stars ſcattered about the Heavens, out of any of the Conſtellations, which are called *Unformed Stars*.

Some remarkable Parcels of Stars, in ſome of the Conſtellations, have alſo obtained Names by themſelves; as the *Pleiades*, or ſeven Stars *, in the Conſtellation *Taurus*; *Charles's Wain*, which are ſeven bright Stars in the hinder Part of the *great Bear*: the three in his Tail are ſuppoſed to repreſent the three Horſes, and the other four the Wain. The two hindermoſt Stars in the Wain are alſo called the *Pointers*, becauſe they point to the Pole Star, which is in the Tip of the Tail of the little Bear; that is, a Line drawn thro' theſe two Stars, and protracted as far as the Pole, will nearly touch the Pole Star.

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* Of which only ſix are now viſible to the naked Eye, *See* Chap. XI.

Many ſingle Stars alſo, eſpecially of the firſt and ſecond Magnitude, have particular Names given them; as *Sirius*, in the great Dog; *Aldebaran*, or the Bull's Eye; *Procyon*, in the little Dog; *Arcturus* in Bootes; *Regel*, in Orion; the *Lion's Heart*; and *Deneb*, in his Tail; *Spica Virginis*, or the Ear of Corn in the Virgin's Hand; *Caſtor* and *Pollux*, in the Conſtellation Gemini; and ſeveral others.

The *Galaxy*, or Milky Way, is a broad, irregular, whitiſh Circle, in ſome Places double, but for the moſt part ſingle, ſurrounding the whole Heavens. Modern Aſtronomers have diſcovered, by their Teleſcopes, that there is an innumerable Multitude of Stars in thoſe Parts of the Heavens, which are too ſmall to be diſtinguiſhed by the naked Eye, whoſe united Rays occaſion the ſhining Whiteneſs of that Circle *. And to the ſame Cauſe they aſcribe ſome other bright Spots in the Heavens, as particularly the *Præſepe*, or Aſſes and Manger, in the Conſtellation *Cancer*.

As for the Connection betwixt the ſeveral Parcels of Stars, which form the Conſtellations, and the Figures after which they are named, it can hardly be diſcovered

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* Theſe are called *Stellæ Nebuloſæ*.

vered in the Conſtellations themſelves; except perhaps in a very few of them, as *Charles's Wain* may be ſuppoſed a little to repreſent a Wain or Waggon with three Horſes; but a very ſtrong Imagination would find it extremely difficult to diſcover any ſuch natural Reſemblance, betwixt the Bulk of the Conſtellations, and the Figures they are named by. The Author of *Spectacle de la Nature*, Vol. I. has an ingenious Conjecture on this Head, *viz.* He conceives it highly probable that the Zodiacal Conſtellations were firſt formed and named by the *Egyptians*, who dealt much in Hieroglyphics, or myſtic Figures; by which they expreſſed, in a covert Manner, The Doctrines and Secrets of their Religion, Philoſophy and Politicks. Thus a *Lion* was the Hieroglyphic of Strength and Fortitude, a *Horſe* of Liberty, a *Circle* of Eternity, *&c.* Now this Author imagines the twelve Signs of the Zodiac were ſuch *Egyptian* Hieroglyphics, by which they deſigned to expreſs or repreſent ſome remarkable natural Occurrence in each Month of the Year, as the Sun was paſſing thro' the reſpective Conſtellations.

The firſt three Months, beginning from the vernal Equinox, were remarkable for the Production of thoſe Animals which they moſt uſed and valued, *viz. Sheep*, *Kine* and *Goats.* The *Lambs* come firſt, which are repreſented by their Parent the *Ram*; next the *Calves*, repreſented by the *Bull*; and then the *Kids*, which commonly come in Pairs, and which therefore gave the Name to the third Conſtellation. But inſtead of the *Twin Kids*, the *Greeks* have ſince ſubſtituted the *Twin Brothers Caſtor* and *Pollux*.

When, in the fourth Month, the Sun is arrived at the Summer Solſtice, he diſcontinues his progreſs towards the North Pole, and begins to go back again to the Southward; which retrograde Motion the *Egyptians* expreſſed by the *Crab*, which is ſaid to go backward.

The exceſſive Heat that uſually follows in the next Month is ſignified by the *Lion*, an Animal remarkable for his Strength and Fierceneſs.

Nothing could be more proper than the Symbol for the Harveſt Month, *viz.* the *Virgin Reaper or Gleaner with an Ear of Corn in her Hand.* Our Author here Remarks by the Way that the *Arabic* Name for the Ear of Corn, *viz. Sibbula* or *Sibbul*, was probably given to the Virgin who carried it, and might give riſe to the Fable of the *Erythræan Sibyl*, who was inſpired to foretel Years of Plenty or Scarcity; and from whom ſome other Women, who pretended to the Gift of Prophecy, were likewiſe

wiſe called *Sibyls*, as the *Delphic Sibyl*, the *Cumæan Sibyl*, &c.

The ſeventh Conſtellation, when the Sun arrives at the Autumnal Equinox, is expreſſed by the *Ballance*, or *Pair of Scales in Equilibrio*, becauſe Days and Nights are then every where equal.

October is often a ſickly Seaſon, when the Surfeits got in the hot Months of the Summer produce their fatal Effects; the Symbol is therefore the *Scorpion*, who wounds with a Sting in his Tail, as he is going away.

The Diverſion of Hunting, which is chiefly followed after the Fall of the Leaf, is ſignified by the *Sagittary* or *Archer*; which the *Greeks* have probably changed into the fabulous *Centaur*.

As the *Crab*, which goes backward, ſignified the Summer Solſtice, when the Sun begins to go back from the Northern Tropic, ſo the *Goat*, which delights to browſe up Hill, is the Symbol of the Winter Solſtice, when the Sun begins to aſcend from the Southern Tropic, and is continually mounting higher and higher for the enſuing half Year.

Aquarius, or the *Water Pot*, fitly repreſents the Rains and Snows of the Winter. And,

The two Fiſhes in a Band, had probably a Re-a Reference to the Prime fiſhing Seaſon, which begins in *February*.

As for the reſt of the Conſtellations, which are out of the Zodiac, the Bulk of them were formed by the *Grecians*, who imitated the *Egyptians* in giving the Names of Men and Animals to Parcels of Stars; but without any ſuch particular Reaſons as the *Egyptians* had for naming the twelve Signs of the Zodiac.

This is the Subſtance of what that Author ſays upon this Subject. How far he has hit on the Truth of the Caſe, cannot now be determined; however,

> This I dare boldly tell,
> 'Tis ſo like Truth, 'twill ſerve our Turn as well.
> COWLEY.

CHAP. V.

The Uſe of the Globes.

PROBLEM I. To find the *Latitude* and *Longitude* of any given Place on the Terreſtrial Globe.

Bring the Place to the graduated Edge of the brazen Meridian; then the Degree marked on the Meridian over it ſhews its Latitude; and the Degree of the Equator, then under the Meridian, ſhews its Longitude. Hence, if the Latitude and Longitude of any Place be given, the Place is eaſily found, by bringing the given Longitude to the Meridian, for then the Place will lie under the given Degree of Latitude upon the Meridian.

Prob. II. To find the Diſtance of any two Places on the Terreſtrial Globe.

Lay the Quadrant of Altitude on both Places; or take the Diſtance between them with a Pair of Compaſſes, and apply it to the Equator. The Number of Degrees on the Quadrant between them, or betwixt the Feet of the Compaſſes on the Equator, reduced to Miles, (that is, 70 to a Degree) ſhews their Diſtance in Miles. In the ſame manner the Diſtance of any two Stars may be found on the Celeſtial Globe, in Degrees, tho' not in Miles *.

Prob. III. To find the *Antæci*, *Periæci*, and *Antipodes*, of any given Place.

Bring the given Place to the Meridian, and obſerve its Latitude. The ſame Latitude, counted towards the contrary Pole, and under the ſame Meridian, ſhews the

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* Becauſe not knowing their Diſtance from us, we cannot tell the value in Miles of their Orbits.

Place of the *Antæci.* Keep the given Place under the Meridian, ſet the Hour-Index to 12 at Noon, then turn to the Globe till the Index Points to 12 at Night, and the Place that is now under the ſame Degree of the Meridian, that the firſt given Place was, is that of the *Periæci.* The *Antipodes* of the firſt Place are now under the ſame Degree of the Meridian that the *Antæci* were before.

PROB. IV. To rectify the Globe for the *Latitude*, *Zenith*, and *Sun's Place.*

1. For the *Latitude*; Elevate the Pole above the Horizon, according to the Latitude of the Place.

2. For the *Zenith*; Screw the Quadrant of Altitude on the Meridian, at the given Degree of Latitude, counting from the Equator towards the elevated Pole.

3. For the *Sun's Place*; Bring the Sun's Place in the Ecliptic (found in the Kalendar on the wooden Horizon, againſt the Day of the Month) to the Meridian, and ſet the Hour-Index to twelve at Noon.

PROB. V. The Hour being given at any Place, to find what Hour it is in any other Part of the World.

Bring the given Place to the Meridian; and ſet the Hour-Index to the given Hour; then, by turning the Globe, bring any Place to the Meridian, and the Index will point to the Hour at that Place.

Prob. VI. The Day and Hour at any Place being given, to find where the Sun is in the *Zenith* at that Hour.

Bring the Sun's Place to the Meridian, and note the Degree over it (which is the Sun's Declination at that time;) then bring the given Place to the Meridian, and ſet the Index to the given Hour; turn the Globe till the Index points to 12 at Noon, and the Place on the Globe, which lies under that Degree of the Meridian that was before noted, has the Sun juſt then in its *Zenith*.

Prob. VII. The Day and Hour being given, to find all thoſe Places of the Earth where the Sun is *Riſing*, *Setting*, or *Culminating*; and alſo where it is *Day-light*, *Twilight*, or *Dark-night*.

Find the Place where the Sun is vertical at the given Hour (by Prob. VI.) rectify for the Latitude of that Place, and bring it to the Meridian. Then all the Places that are in the Weſt Semicircle of the Horizon, have the Sun *riſing*; thoſe in the Eaſt Semicircle have it *ſetting*; thoſe under the Meridian, above the Horizon, have it *culminating*; and all Places above the Horizon, have the Sun ſo many Degrees above the Horizon as the Places themſelves are. Thoſe Places that are below the Horizon, but within 18 Degrees of it, have *Twilight*; and thoſe lower than 18 Degrees have *Dark-night*.

PROB. VIII. Any Place, whoſe Latitude is leſs than 66½ Degrees, being given, and the Day of the Month; to find at what Hour the Sun riſes and ſets, and the Length of Day and Night.

Rectify for the Latitude and Sun's Place; then bring the Sun's Place to the Eaſt or Weſt Part of the Horizon, and the Index will point to the Hour of the Sun's riſing, or ſetting; and the Hour of his riſing, or ſetting, doubled, gives the Length of the Night, or Day.

PROB. IX. Any Place, whoſe Latitude is more than 66½ Degrees North, being given, to find the Time when the Sun begins to appear above the Horizon, and when it begins to diſappear;

and alſo the Length of the longeſt Day or Night in that Place.

Rectify for the Latitude, bring the aſcending Part of the Ecliptic * to the South Point of the Horizon, obſerve the Degree of the Ecliptic which cuts that Point, and ſee in the Kalendar what Day the Sun enters into that Degree, for that is the Day when the Sun begins to appear in that Latitude. In like manner bring the deſcending Part of the Ecliptic to the ſame Point of the Horizon, and the Kalendar will ſhew, as before, when the Sun leaves that Latitude, and entirely diſappears. Again, bring the aſcending Part of the Ecliptic to the North Point of the Horizon, note the Degree, as before, and the Kalendar will ſhew when the longeſt Day begins; bring the deſcending Part of the Ecliptic to the ſaid North Point, and you will find, by the ſame Method, when the longeſt Day ends. *N. B.* The longeſt Night is every where equal to the longeſt

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* *N. B. The aſcending Part of the Ecliptic* is that in which, while the Sun proceeds in his annual Courſe, he is daily aſcending, or riſing higher and higher every Day at Noon. *The deſcending Part* is that in which he is daily deſcending, or falling lower and lower. Thus, in all Latitudes that lie North of the Tropic of Cancer, the aſcending Part is the Semicircle from Capricorn to Cancer; but in Latitudes South of the Tropic of Capricorn, it is the Semicircle from Cancer to Capricorn.

Day. Thus, at the North Cape of *Lapland*, 71 Degrees Latitude, the Sun begins to appear above their Horizon, when he arrives at about 6 Degrees of *Aquarius*, that is, on the 25th or 31st of *January*. Their longeſt Day begins near the Middle of *May*, and the Sun continues above their Horizon, without ſetting any more, till near the End of *July*. And he goes entirely below their Horizon, and their longeſt Night begins, near the Middle of *November*. So that their longeſt Day, and longeſt Night, are each of them upwards of two Months.

PROB. X. The Latitude of any Place being given, and the Day of the Month, to find the *Beginning*, and *End*, and *Duration* of *Twilight*, and of *Dark-night*.

Rectify for the Latitude, Zenith, and Sun's Place; bring the Point of the Ecliptic which is oppoſite to the Sun's Place, by turning the Globe weſtward, or eaſtward, to cut 18 Degrees of the Quadrant of Altitude; then will the Index ſhew when Twilight begins, or ends. And the Time when Twilight begins, taken from the Time of the Sun's Riſing, (found by *Prob.* 8.) leaves the Duration of Twilight. And the Time when Twilight begins, doubled, gives the Length of Dark-night.

Prob. XI. The Latitude, Day of the Month, and Hour being given, to repreſent the Face of the Heavens, at that Time, on the Celeſtial Globe.

Rectify for the Latitude, and Sun's Place; ſet the Globe on an Horizontal Plane, with its cardinal Points directed to the correſponding cardinal Points in the Heavens; turn the Globe eaſtward or weſtward till the Index points to the given Hour: then does the Surface of the Globe repreſent the Face of the Heavens, in relation to the Horizon of the given Place, at that Hour; exactly, if it be 12 at Noon, and pretty nearly if it be any other Hour.

Prob. XII. To find the *Latitude* and *Longitude* of any *given Star*.

Put the Center of the Quadrant of Altitude on the Pole of the Ecliptic, and its graduated Edge on the given Star; then the Arch of the Quadrant, intercepted betwixt the Star and the Ecliptic, ſhews its Latitude; and the Degree which the Edge of the Quadrant cuts on the Ecliptic, is the Degree of its Longitude.

Prob. XIII. To find the *Declination* and *Right-Aſcenſion* of the *Sun*, or any *Star*.

Bring the Sun's Place for any given Time, or the Star, to the Meridian; then the Degree of the Meridian over it ſhews its Declination; and the Degree of the Equinoctial at the Meridian, ſhews its Right-Aſcenſion.

PROB. XIV. The Place and Day being given to find the *Sun* or *Star's eaſtern* or *weſtern Amplitude*, *oblique Aſcenſion* and *Deſcenſion*, *aſcenſional Difference*, and *ſemidiurnal Arch*.

Rectify for the Latitude and Sun's Place; bring the Sun's Place, or the Star, to the eaſt or weſt Part of the Horizon; then the Arch betwixt it and the eaſt or weſt Point of the Horizon, ſhews its eaſtern, or weſtern *Amplitude*. The Degree of the Equinoctial, where it cuts the Horizon, ſhews the *oblique Aſcenſion*, or *Deſcenſion*; and the difference betwixt the right and oblique Aſcenſion, (or if it be of the Sun, the difference betwixt the Hour which the Index points to, and Six) is the *aſcenſional Difference*; which being converted into Time, and added to Six, when the Sun, or Star, declines towards the elevated Pole, (*i. e.* in northern Latitude, when it has north Declination) or ſubſtracted from Six, when it declines towards the depreſſed Pole, gives half the Time of its Stay above the Horizon; which, when we ſpeak of the Sun, is called the *ſemidiurnal Arch*. The Compliment of the ſemidiurnal Arch to Twelve, gives the *ſeminoctурnal Arch*, or half the Time of its ſtay below the Horizon. The Sun's ſemidiurnal Arch, computed from Noon, gives the Time of his Setting; and his ſeminocturnal Arch, computed from Midnight, gives the Time of his Riſing.

Prob. XV. The Latitude and Sun's Place being known, then, if either the *Hour of the Day, or Night*, or the *Altitude*, or *Azimuth*, of the *Sun*, or *Star*, be given, to find the other two.

Rectify for the Latitude, Zenith, and Sun's Place; then

1. If the *Hour* be given, turn the Globe till the Index points to it, and bring the Quadrant of Altitude down to the Sun or Star's Place; ſo will the graduated Edge ſhew the Degree of Altitude; and the Degree of the Horizon, where the Quadrant cuts it, ſhews the Azimuth.

2. If the *Altitude* be given, bring the Sun or Star's Place to meet with the Quadrant at the given Altitude; then the Index will point to the Hour, and the Interſection of the Quadrant and Horizon will ſhew the Azimuth.

3. If the *Azimuth* be given, bring down the Quadrant to interſect the Horizon at the given Azimuth; then, by turning the Globe, bring the Sun's Place or Star, to meet with the Quadrant, and the Degree on the Quadrant where they meet, ſhews the Altitude, and the Index points to the Hour.

Hence, if the Altitude and Azimuth of any Star in the Heavens be taken by Obſervation with proper Inſtruments, it is eaſy to find that Star on the Globe; and, by taking the Altitude and Azimuth of any Star upon the Globe at a given Hour, the ſame Star may be found in the Heavens *.

PROB. XVI. The Latitude of a Place being given; to find the *Coſmical*, *Achronical*, and *Heliacal* riſing or ſetting of any given Star.

Rectify for the Latitude; then

1. Bring the Star to the eaſt or weſt Part of the Horizon, obſerve the Degree of the Ecliptic then riſing; over againſt this Degree in the Kalendar is found the Day of

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* In taking the Altitude of the Sun, or a Star, by Obſervation, Allowance muſt be made for the Refraction or bending of the Rays of Light, in their Paſſage through the Atmoſphere; which is greateſt near the Horizon, and decreaſes toward the Zenith, ſo as to be ſcarce ſenſible after 30 Degrees. See a Table of Refractions to 75 Degrees, made by Sir *Iſaac Newton*, in N° 368 of the *Philoſophical Tranſactions*, and in *Ferguſon*'s *Aſtronomy*, p. 66.

the Star's *Coſmical* riſing or ſetting. Thus Lat. 51½ N. *Sirius* riſes coſmically *Auguſt* 11, ſets coſmically *November* 16.

2. Bring the Star to the eaſt or weſt Part of the Horizon, obſerve the Degree of the Ecliptic then ſetting; and over againſt it in the Kalendar is found the Day or the Star's *Achronical* riſing or ſetting. Thus *Sirius* riſes achronically *February* 6th, ſets *May* 14.

3. Rectify for the Zenith, bring the Star to the eaſt Part of the Horizon, and bring down the Quadrant of Altitude on the weſtern Side, to cut the Ecliptic at that Degree of the Quadrant, which is the Star's Arch of Viſion, (which, if it be a Star of the firſt Magnitude, is the 12th Degree from the Horizon;) obſerve the Degree of the Ecliptic, which is thus cut by the Quadrant, (which, when the Star riſes, is twelve Degrees high above the weſtern Horizon; and, conſequently, the oppoſite Point to this in the Ecliptic is twelve Degrees below the eaſtern Horizon,) look the oppoſite Point in the Kalendar, and you have the Day of that Star's riſing heliacally. Again, bring the Star to the weſt Part of the Horizon, and the Quadrant to the eaſt Side, till the 12th Degree of it cuts the Ecliptic; look for the oppoſite Point of the Ecliptic to that which is thus cut by the Quadrant, and find when the Sun comes to that Point

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which gives the Time of the Star's heliacal ſetting. Thus *Sirius* riſes heliacally *Auguſt* 26, ſets *April* 27 *.

PROB. XVII. The Day of the Month being given; to find when any Star will come to the Meridian.

Rectify for the Sun's Place, turn the Globe till the given Star comes to the Meridian; then the Index will point to the Time ſought.

PROB. XVIII. To find when a given Star will come to the Meridian; at any given Hour of the Night.

Bring the given Star to the Meridian, ſet the Index to 12 at Noon; then turn the Globe

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* From the heliacal riſing of *Sirius*, the Ancients reckoned their *Dies Caniculares*, or *Dog-Days*, to 30, 40, or 50 Days after it, for they were not all agreed how long the Dog-Days laſted. However, it was the common received Opinion, that the ſultry Weather at that Seaſon of the Year was owing to this Star. The *Romans* in particular, were ſo perſuaded of its malignant Influence, that they are ſaid to have ſacrificed a brown Dog annually on the Day of its riſing, to appeaſe its Rage. But that this was all a groundleſs Conceit is very evident; for though in their Time *Sirius* roſe about the 28th or 29th of *July*, when the Weather is commonly hotteſt, yet now he does not riſe till the latter End of *Auguſt*, when, in moſt Years, the hotteſt Seaſon is over. And if the World ſhould continue five or ſix Thouſand Years more, he will not riſe until *November* or *December*, when he may happen to be charged with bringing Froſt and Snow, inſtead of Heat. However, our Almanack-makers ſtill continue to mark the Beginning of the *Dog-Days* about the 29th of *July*, and their End about the 8th of *September*.

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Globe eaſtward, till the Index points to an Hour as far diſtant in the Forenoon from 12, as the given Hour is in the Afternoon: Obſerve the Degree of the Ecliptic then at the Meridian, over-againſt which Degree, in the Kalendar, is the Day of the Month when the given Star will be upon the Meridian, at the given Hour.

PROB. XIX. The Latitude of the Place being given; to find the *Hour of the Day* by the Globe when the Sun ſhines.

Set the Globe on an horizontal Plane, with the Meridian due North and South.

1. In the Summer half Year, elevate the Pole above the North Part of the Horizon, according to the given Latitude.

2. In the Winter half Year, depreſs the ſame Pole as much below the South Part of the Horizon; then the Shade of the Axis upon the Hour-Circle will ſhew the Hour of the Day.

PROB. XX. By Obſervation of a Star upon the Meridian, to find the *Hour of the Night*.

Rectify for the Latitude and the Sun's Place; bring the given Star to the Meridian, and the Index will ſhew the Hour of the Night.

PART II.

The SOLAR SYSTEM, *and the Uſe of the* ORRERY.

CHAPTER I.

A general View of the Univerſe.

THE heavenly Bodies, which are viſible from the Earth, are *Sun*, *Moon*, and *Stars*.

The Stars are of two Sorts. One Sort (of which there is by far the greater Number) are called *fixed Stars*; becauſe they always appear in the ſame Places, or at the ſame Diſtance, from one another. The other Sort of Stars are called *Planets*, or wandering Stars; becauſe they are perpetually changing their Places and Diſtances, both with regard to the fixed Stars, and one another.

The Planets may eaſily be diſtinguiſhed from the fixed Stars, by their not twinkling, as the fixed Stars do, excepting thoſe of them which are vertical, or nearly ſo *. And generally the Planets are the Stars which appear ſooneſt in the Evening, and are lateſt ere they diſappear in the Morning; therefore it is one of the Planets that is the Morning or Evening Star.

The fixed Stars are at ſuch immeaſurable Diſtances from the Earth, that we know but very little of them. The *Sun*, *Moon*, and *Planets*, are much nearer to us, and are better known.

The Sun is a great burning Globe, or fiery Ball, whoſe Diameter is computed to be 763,000 Miles. It always remains immovable in the vaſt Expanſe, except that it is obſerved to turn round its own Axis in about twenty-five Days and a half.

Many dark Spots, of various irregular Figures, may commonly be ſeen, with Teleſcopes, in the Surface of the Sun; by means of which his Rotation on his Axis has been diſcovered, and the Time of it aſcertained. Theſe Spots are not very permanent, but ſome of them diſappear again in a few Days after their firſt Appearance. Others of them have been obſerved to continue during four or five Rotations of the Sun's Body.

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* Which the Planets cannot be in our Latitude.

The Planets are round opake Bodies, which have no Light of their own, but reflect the Light of the Sun.

The Planets, and the Earth (which is truly a Planet) are continually moving round the Sun in Circles, or rather in Ellipſes, or Ovals, of different Bigneſſes, in the following Order.

1. ☿ Mercury is neareſt the Sun, and performs his Revolution in about three Months.

Fig. II.

N. B. This Planet is always ſo near the Sun that it is ſeldom ſeen.

2. ♀ Venus is next, and revolves in about ſeven Months and a half.

3. ⊕ The Earth in a Year.

4. ♂ Mars in about two Years.

5. ♃ Jupiter in about twelve Years.

6. ♄ Saturn in about thirty Years.

The Space of Time in which each Planet revolves round the Sun, is alſo called that Planet's Year. Thus Saturn's Year is equal to about Thirty of ours.

Theſe Six are the primary Planets. Some of them have ſecondary Planets, or Satellites, or Moons, moving continually round them. As the *Moon* round the Earth. Jupiter has four Moons, Saturn has five.

The Planets are of different Magnitudes; ſome are bigger than the Earth, others are leſs. Mercury is ſeven Times leſs than the Earth; Venus nearly equal to the Earth;

Mars ſix times leſs; Jupiter one thouſand ſeven hundred and twenty-eight times bigger; Saturn ſix hundred times bigger; the Moon is ſixty times leſs than the Earth *.

A Machine which repreſents the Motions of the Planets, is called an ORRERY. And it will very well anſwer the purpoſe, if it repreſents only the Motions of two primary Planets, for Inſtance, the *Earth* and *Venus*; and of one ſecondary Planet, *viz.* the *Moon*: for as the others move in the ſame Manner, a ſufficient Notion may be formed by theſe, of the Motions of all the reſt.

The proportionable Magnitudes, and reſpective Diſtances of theſe Bodies to one another,

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* The Syſtem of the World here deſcribed, is called the *Pythagorean* or *Copernican* Syſtem; as having been anciently taught by the wiſe *Samian* Philoſopher *Pythagoras*, and revived, after it had been in a manner loſt, by the famous *Poliſh* Philoſopher, *Nicholas Copernicus*, who was born at *Thorn*, in the Year 1473.

The moſt famous of the antiquated, and now juſtly exploded Syſtems, are the *Ptolemean* and the *Tychonian*.

The PTOLEMEAN Syſtem (held long before by *Ariſtotle* and *Hipparchus*) was taught by *Ptolomy* an *Egyptian* Aſtronomer, who is ſaid to have lived 138 Years before Chriſt. He ſuppoſed the Earth to be immovably fixed in the Center of the Univerſe, and the ſeven Planets, *viz.* the *Moon*, *Mercury*, *Venus*, the *Sun*, *Mars*, *Jupiter*, and *Saturn*; and, above them all, the Firmament of fixed Stars, to be conſtantly revolving round the Earth in twenty-four Hours from Eaſt to Weſt.

The TYCHONIAN Syſtem was taught by *Tycho Brahe*, a noble *Dane*, who was born A. D. 1546. It ſuppoſes the Earth to be fixed and immovable, as the *Ptolemean* Syſtem does; and that all the Stars and Planets revolve round another, are not to be conveniently expreſſed in an Orrery. For ſuppoſe a Ball of one Inch Diameter to repreſent the Earth, then the Ball that repreſents the Sun ſhould, in true Proportion, be very near eight Feet Diameter, (the Sun being 885,736 times bigger than the Earth) and the Diſtance of the Earth from the Sun ſhould be about 284 Yards, which is more than half a Quarter of a Mile.

round the Earth in twenty-four Hours: but it differs from the *Ptolemean* in that it not only allows a menſtrual Motion to the *Moon* round the *Earth*, as the Center of its Orbit, but it makes the *Sun* to be the Center of the Orbits of *Mercury*, *Venus*, *Mars*, *Jupiter*, and *Saturn*, in which they are carried round the *Sun* in their reſpective Years, as the *Sun* is round the Earth in a Solar Year: and all theſe Planets, together with the Sun, are ſuppoſed to be whirled round the Earth in twenty-four Hours.

This Hypotheſis is ſo embarraſſed and perplexed, that but few Perſons embraced it. It was afterwards refined upon by *Longomontanus*, and ſome others; who allowed the diurnal Motion of the Earth on its own Axis, but denied its annual Motion round the Sun. This Hypotheſis, partly true and partly falſe, is called the *Semi-Tychonian* Syſtem. However, the *Pythagorean* Syſtem has generally been received by the greateſt Mathematicians and Philoſophers, ever ſince the Revival of it by *Copernicus*: and it has been at length eſtabliſhed on ſuch a ſolid Foundation of mathematical and phyſical Demonſtration, by the great Sir *Iſaac Newton*, as puts it out of all Danger of being ever overthrown by any new contrived Syſtem, ſo long as the Sun and Moon ſhall endure.

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CHAP. II.

Of the Earth, and its Motions.

THE natural Earth is nearly a Globe, or round Ball, whoſe Diameter is 7,940 Miles *. Its mean Diſtance from the Sun is 81,000,000 Miles †.

Note, The Earth being further off from the Sun at one Time of the Year than another (as will be ſhewn afterwards) by the *mean Diſtance* is meant the Medium betwixt the two Extremes; or a Line drawn from the Earth to the Sun, which exceeds the ſhorter Diſtance, as much as it falls ſhort of the longer.

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* The Unevenneſs of the Surface of the Earth, as conſiſting of Mountains and Valleys, is no material Objection againſt its being conſidered as round; ſince the higheſt Mountains do not bear near ſo great a Proportion to the Bulk of the Earth, as the little Riſings in the Coat of an Orange bear to the Bigneſs of that Fruit.

† Since by accurate obſervation on the Tranſit of *Venus* in 1761, the Sun's Parallax (of which ſee *Chap.* 10) is found to be only about $8'' \frac{1}{2}$ inſtead of 10″, the diſtance of the Sun will be greater than that here aſſigned, *viz.* near 95,000,000 Miles, as well as the diſtance of the Planets, mentioned *Chapter* VII. their Magnitudes, and Velocities. *See the Philoſophical Tranſactions, Vol.* 53, *at the beginning.*

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The Axis of the Earth is inclined to the Plane of the Ecliptic, making with it an Angle of 66 ½ Degrees, or with a Perpendicular to the Plane of the Ecliptic, an Angle of 23½ Degrees.

Note, The Plane of the Ecliptic is an imaginary Plane, paſſing thro' the Center of the Sun, and of the Earth.

The Earth has a double Motion. *Firſt*, its diurnal Motion, round its own Axis, in twenty-four Hours. *Secondly*, its annual Motion round the Sun in a Year.

Firſt, It has a diurnal Motion, which occaſions the perpetual Succeſſion of Days and Nights.

One Hemiſphere of the Earth is always illuminated by the Sun; and the Circle of Illumination, or the Boundary of Light and Shade, is perpendicular to the Plane of the Ecliptic.

When any Point on the Globe firſt gets into the enlightened Hemiſphere, the Sun is juſt riſen to that Part; when it gets half Way, or to its greateſt Diſtance from the Circle of Illumination, it is then Noon; and when it leaves the enlightened Hemiſphere, it is then Sun-ſet *. But ſtill it enjoys ſome Light from the Sun, reflected by the Atmoſphere, or Air, until it is got 18 Degrees beyond the Circle; which glimmering Light is called *Twilight.*

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* The Sun riſes, in Appearance, ſome time before the Place on which he riſes is got within the Hemiſphere that is obverted to the Sun; and he does not ſet till ſome time after it has left that Hemiſphere: which is occaſioned by his

Suppoſe a *Peach* to repreſent the Earth, the *Down* on the *Peach* will fitly enough repreſent the Atmoſphere; the Height of which is computed at about *fifty Miles:* for when the Sun is got 18 Degrees below the Horizon, his Rays will not reach lower than about 50 Miles over our Heads, and then we find the Twilight is gone, and we can ſee the ſmalleſt Stars that are viſible to the naked Eye. So that there does not ſeem to be any Air above that Height to reflect the Light of the Sun to us.

N. B. Thoſe parts of the Earth that lie at more than 48 Degrees Latitude, have no perfect Night at all, at the Seaſon of their longeſt Days, but Twilight only.

As the Earth moves round its own Axis, from Weſt to Eaſt, in twenty-four Hours, all the heavenly Bodies muſt appear to move

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his Rays being refracted, or bent, in paſſing through the Earth's Atmoſphere. And as the Degree of the Refraction at the Horizon is about 34 Minutes, which is more than the Sun's Diameter, his whole Body becomes viſible before he is riſen; that is, before a right Line drawn from the upper Edge of the Sun's Diſk could reach the Eye of the Obſerver: and in the ſame Manner he continues to be viſible after he is ſet. Hence the Length of Days is ſomewhat more than is expreſſed in the Tables of the Sun's riſing and ſetting.

round the Earth, from Eaſt to Weſt, in the ſame Time.

The Rays of the Sun, when he is near the Horizon, paſs thro' a much larger Body of Air, (by which the Force of the Light is much weakened,) than when he is near the Zenith.

Hence it is that we can look upon the Sun, at his riſing, or ſetting, without hurting our Eyes, which we are not able to do when he is at the Meridian. Let O B F Fig. III. repreſent the Earth, *a* L *m* the Orb of Air, or the Atmoſphere which ſurrounds it. Let O be the Place of Obſervation, *a m* the apparent or ſenſible Horizon: Then O *a* is the Length of that Portion of the Atmoſphere, thro' which the Sun is ſeen at the Horizon, which is longer than O *i*, thro' which he is ſeen in the Zenith *.

From hence alſo † we may perceive the Reaſon why the Sky (which is nothing elſe but the terreſtrial Atmoſphere, thro' all Parts of which either the Rays of Light are tranſmitted to us from the heavenly Bodies, or they are reflected to us from it) appears not as an Hemiſphere, but a depreſſed Arch, as *a i m*.

Hence alſo the Reaſon is evident, why a Degree of the Sky, at or near the Horizon, appears longer than a Degree at or near the Zenith; and why Degrees ſhorten in their Appearance from the Horizon to the Zenith: For though the Angles H O S, D O E, and V O Z, are all equal, each of them meaſuring the ſame Number of Degrees on the Arch of the Circle in the Heavens, A D Z *, yet the Portion of the Sky *a b* is greater than *c d*; and that again is greater than the Portion *e i*.

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* Eucl. III. 7.

† That is becauſe we are not in the Centre.

From hence, perhaps, may ariſe the Cauſe of the Sun and Moon, and the Starry Conſtellations, appearing ſo much larger when they are ſeen near the Horizon, than when they have conſiderable Altitude. Let H S repreſent the Sun at the Horizon, V Z the Sun at the Zenith; now when the Sun is at the Horizon, the Portion of the Sky *a b* is enlightened by his Rays paſſing directly from the Body of the Sun to the Eye at O; or a Cone of Air, whoſe Baſe is *a b*, and whoſe Vertex is O, is illuminated with his direct Rays, while his Light is only reflected to the Eye at O, from all the other Parts of the Atmoſphere. But when the Sun is in the Zenith, he is ſeen directly thro' the ſmaller Portion of the Sky *e i*, and only the leſſer Cone *e i* O is illuminated with his direct Rays. And as 30 Minutes of a Degree (which is nearly the Sun's apparent Diameter) appear ſhorter toward the Zenith, than toward the Horizon; therefore the Diameter and Diſk of the Sun, appears leſs at his Meridian Altitude, than when he is riſing or ſetting.

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* Tho' the Arch A D Z is in this Figure, an Arch of a Circle deſcribed on the Center T, not on O, as it ſhould be on Suppoſition that H S and V Z contain the ſame Number of Degrees, and therefore that the Angles H O S and V O Z are equal; Yet the Diſtance betwixt T, the Earth's Center, and O on its Surface, being next to nothing, in Compariſon with the Diſtance of a Circle in the Heavens, repreſented by the Arch A D Z, from the Earth, (as it will be ſhewed preſently) it is much one, in this Caſe, whether that Arch be deſcribed on the Center T, or O: And therefore the Angles H O S, D O E and V O Z may very well be conſidered as all Equal.

Or perhaps we may more eaſily conceive the Matter thus. When the Sun is in the Horizon, that Portion of the outward Surface of the Atmoſphere which receives its Rays, that are tranſmitted thro' it directly to our Eyes is larger, and conſequently receives a larger Bundle of Rays than when he is higher; therefore he appears to us ſo much larger when he is riſing and ſetting, than at his Meridian Altitude.

This Figure may further ſhew, how the ſenſible and the rational Horizon approach nearer to be the ſame, the further an Object is off from the Earth. For though the Diſtance between them is always the ſame, *viz.* T O, or a Semidiameter of the Earth; yet the greater the Circle is in which the Object is ſeen, the leſs is the Semidiameter of the Earth in proportion to it. Thus T O bears a much greater Proportion to the Semidiameter of the Earth's Atmoſphere, *viz.* T *i*, than to T Z, the Semidiameter of the larger Circle. Therefore in Circles ſo remote as the Orbits of the heavenly Bodies, the Diſtance betwixt the ſenſible and rational Horizon is not perceptible, but they may be conſidered as one and the ſame; the Semidiameter of the Earth being indeed but a Point, in Compariſon with thoſe vaſt Diſtances.

Secondly, The Earth has an annual Motion round the Sun, which produces the lengthening and ſhortening of Days, and different Seaſons, *viz. Spring*, *Summer*, *Autumn*, and *Winter*.

The Earth, in its annual Motion, has its Axis always in the ſame Direction, or parallel to itſelf.

The Earth completes its Revolution round the Sun in 365 Days, 5 Hours and 49 Minutes. The odd 5 Hours and 49 Minutes, being nearly a Quarter of a Day, occaſion the additional Day every fourth Year, or *Leap Year*. But yet as 4 times 5 Hours and 49 Minutes wants 44 Minutes of a compleat natural Day, or 24 Hours, (which Defect amounts to about 3 Days in 400 Years,) this occaſions the Error of the Old Style, which is at preſent 11 Days behind the New Style, now uſed in moſt Countries of Europe; and in 400 Years more it will be 14.

The Earth's annual Motion is from Weſt to Eaſt; and in the ſame Courſe does the Sun, as ſeen from the Earth, appear to move thro' the Signs of the *Zodiac*.

In whatever Sign the Earth would appear, if ſeen from the Sun; the Sun appears in the oppoſite Sign, as ſeen from the Earth.

The Sign which the Earth is in, is that which appears upon the Meridian at Midnight; from whence we can tell what Sign the Sun is in, tho' we do not ſee the Stars at the Time of his ſhining.

When the Earth enters the Sign *Libra*, the Sun appears to enter the Sign *Aries*, which is about the 21ſt of *March*. Then the Circle of Illumination touches both Poles: the Sun is vertical to the Equator, and Days and Nights are equal all the World over. This is called the *vernal Equinox*.

When the Earth enters *Scorpio*, the Sun enters *Taurus*. The Days are then lengthened every where North of the Equator, and ſhortened South of it.

While the Sun is, in Appearance, travelling thro' *Gemini*, the Days and Nights grow ſtill more unequal.

When he arrives at *Cancer*, the Days are at the longeſt in the Northern Hemiſphere, and at the ſhorteſt in the Southern. And the whole Northern Frigid Zone is got within the Circle of Illumination towards the Sun; conſequently there is no Night there.

The Reverſe is the Caſe in the Southern Frigid Zone. The Sun is now vertical to the Northern Tropic, which, from his entering the Sign Cancer at this Seaſon, is called the *Tropic of Cancer*. This is the *Summer Solſtice.*

As the Sun proceeds thro' *Leo* and *Virgo*, the Days ſhorten in the Northern, and lengthen in the Southern Hemiſphere.

When he arrives at *Libra*, the Days and Nights are again every where equal. This is called the *Autumnal Equinox*, which falls out about the 23d of *September*.

When he comes to *Capricorn*, it is the longeſt Day in the Southern, and the ſhorteſt in the Northern Hemiſphere. This is the *Winter Solſtice.* The Southern Tropic is called the *Tropic of Capricorn*, for the ſame Reaſon that the Northern is called the Tropic of Cancer.

As the Sun proceeds thro' *Aquarius* and *Piſces*, the Days lengthen North of the Equator, and ſhorten South of it; until he arrives at *Aries* again, when the Earth has completed her annual Orbit, and Days and Nights are again every where equal.

The nearer any Place is to the Pole, it has the longer Days in the Summer, and the ſhorter in the Winter. At the Pole the longeſt Day is ſix Months.

In all Poſitions of the Earth, half the Equator is always in the Light, and half in

Darkneſs; therefore at the Equator the Days and Nights are always equal.

The Sun's Declination does not alter ſo faſt; or his Altitude, as ſeen from any Place on the Earth one Day at Noon, does not differ ſo much from his Altitude the next Day at Noon, when he is at or near the Solſtices, as when he is at or near the Equinoxes: becauſe the Ecliptic, in which the Sun appears to move, approaches much nearer to a parallel Poſition to the Equator, where it touches the Tropics, than where it cuts the Equator; and therefore neither does his diurnal Arch, or his apparent Path over the Earth above the Horizon, grow ſo much bigger or leſs, one Day than another; nor conſequently, do the Days lengthen, or ſhorten, ſo faſt about the ſolſticial, as at the equinoxial Seaſons.

The Sun, ſtanding out of the Center of the Earth's annual Orbit *, makes the Summer to the Northern Hemiſphere, longer than the Winter by eight Days: That is, from

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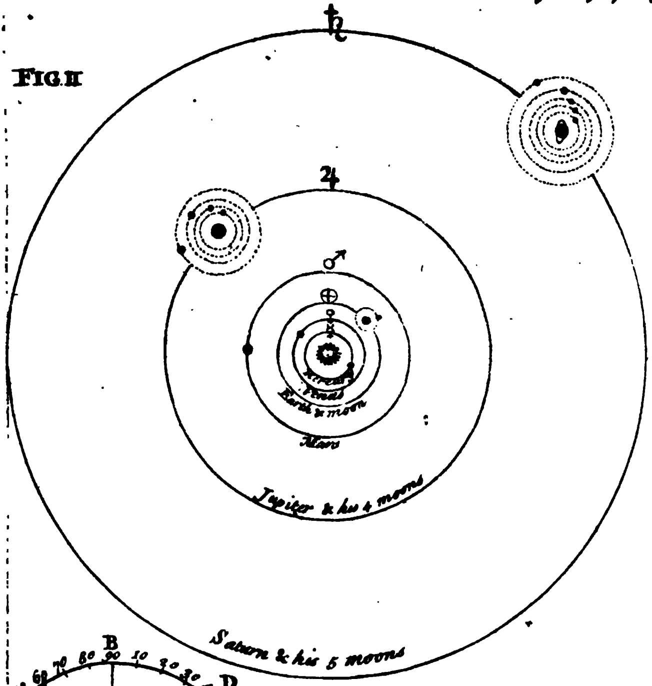
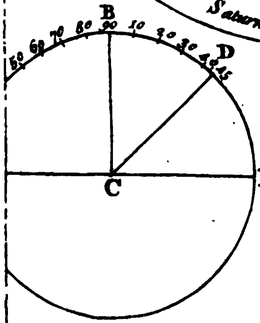
* The Earth's Orbit is in Reality an Oval, or Ellipſe, having the Sun ſtanding in one *Focus*. The *Focus's* of an Ellipſe are two Points in the longer Axis, equally diſtant from the Center, or Middle of it; from each of which, if a right Line be drawn to any Point in the Circumference, both thoſe Lines together are equal to the longer Axis. The longer an Ellipſe is, in Proportion to its Breadth, or the more it differs from a Circle, it is ſaid to be the more *Eccentric*, and the *Focus's* are the further aſunder, and nearer to the Ends. The *Focus* of the Earth's annual Orbit,

facing p. 56.

FIG. II





V.

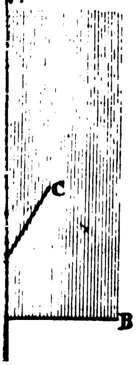
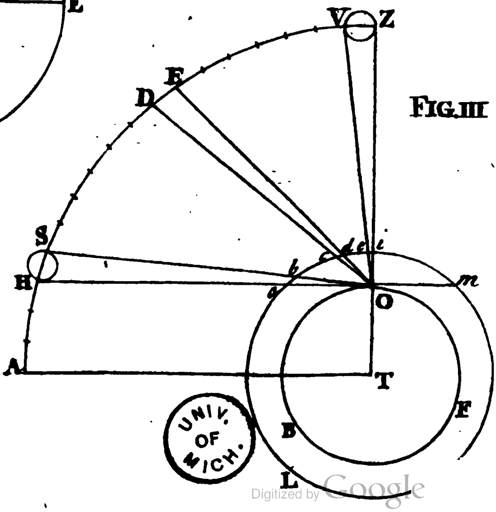


FIG. III



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from the vernal Equinox to the autumnal, is eight Days more, than from the autumnal to the vernal.

The Sun being nearer to the Earth in our Winter, than in Summer, makes the Winters warmer, and the Summers cooler, than they are in the ſame Latitude South of the Equator. Hence alſo the Sun appears bigger to us in Winter than in Summer.

The cauſe of greater Heat in Summer than in Winter is, partly, the Sun's being *longer* above the Horizon; and chiefly, his being *higher* above the Horizon; conſequently his Rays come to the Earth in a Direction more perpendicular to its Surface in the Summer, than in the Winter.

Let A B repreſent a Portion of the Earth's Surface, on which the Sun's Rays fall perpendicular; let A C repreſent an equal Portion, on which they fall obliquely, or aſlant. It is manifeſt that A C, tho' it be equal to A B, receives but half the Rays, and therefore enjoys but half the Light and Heat that A B does.*

Fig. IV.

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bit, in which the Sun ſtands, is that which is nearer to that End where the Earth is at the Winter Solſtice. That Point of the Earth's, or of any Planet's Orbit, wherein it is neareſt the Sun, is called its *Perihelion*. The oppoſite Point, in which it is fartheſt off from the Sun, is called its *Aphelion*.

* And the Force of the Rays it does receive, is leſs in Proportion as the Sine of the Angle of Incidence is to the Radius.

Moreover the Sun being low, and near the Horizon in the Winter, his Beams paſs thro' a much greater Quantity of Air in their Paſſage to us, by which the Force of them is weakened, than when he approaches nearer to our Zenith in the Summer.

The torrid Zone, to one Part or other of which the Sun is always vertical, is therefore hotteſt.

The frigid Zones, tho' they have the longeſt Days, receive the Sun's Rays moſt obliquely, and are therefore coldeſt.

The temperate Zones, to which the Sun is never quite vertical, nor very oblique, enjoy the more moderate Heat.

But yet we do not find the hotteſt Seaſon of the Year to be juſt at the Summer Solſtice, when the Sun is longeſt and higheſt above the Horizon, but generally a Month or two after: which may be thus accounted for. We know that a Body once heated by the Sun, does not grow cold again inſtantaneouſly, but gradually: or the heating Particles which flow from the Sun, do not fly off again all at once, as ſoon as the Sun is withdrawn; but they fly off, or loſe their Force, by Degrees. Now ſo long as more Heat comes from the Sun in the Day than is loſt in the Night, the Heat of the Earth and Air will be daily increaſing. Suppoſe half the Heat of the Day ſhould go off in the Night, and, for Example's ſake, let us ſuppoſe that 100 heating Particles come from the Sun in the Day, 50 only of which fly off in the Night, when, at the Time of the Summer Solſtice, the Night is but half as long as the Day. Suppoſe but 90 heating Particles come from the Sun the next Day; yet 90 + 50 = 140. Suppoſe but 80 new heating Particles come the third Day; yet 80 + 70 (*i. e.* half the Heat of the former Day) = 150; therefore this Day will be ſtill hotter than the laſt. Thus while there are more Particles that excite Heat received in the Day time, than are loſt in the Night, the Heat of the Earth and Air will conſtantly grow ſtronger. But, in Proceſs of Time, as the Action of the Sun in heating grows weaker, and the Nights grow longer, more heating Particles will go off in the Night than were received in the Day; and then the Earth and Air will gradually cool again, till after the Winter Solſtice.

The Earth does not move uniformly in its Orbit, or always with the ſame Degree of Velocity; but ſwifter when it is nearer the Sun, and ſlower when further off. The Medium betwixt the two Extremes of its ſwifteſt and ſloweſt Motion, is called its *mean Motion* *; that is, ſuch a Degree of Velocity,

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* As the Motion of all the primary Planets is ſometimes accelerated, and ſometimes retarded, according to their Diſtance from the Sun; and of the ſecondary Planets, according

city, which as much exceeds the ſloweſt Motion, as it falls ſhort of the ſwifteſt.

The Velocity of the mean Motion of the Earth in its annual Orbit, is computed to be at the Rate of 15½ Miles in a Second of Time, 933 in a Minute, 56000 in an Hour: which is more than 100 Times ſwifter than the Motion of a Cannon Ball, which is uſually reckoned about 7 Miles in a Minute. Any Point on the Earth's Equator moves, by the diurnal Rotation, at the Rate of about 17 Miles in a Minute, and 1020 in an Hour.*

CHAP. III.

Of the Preceſſion of the Equinoxes.

IN the laſt Chapter we ſuppoſed the Axis of the Earth to continue always in one immutable Poſition, or conſtantly parallel to itſelf; but it has been found by the Obſervations of many Years, that this is not preciſely the Caſe; but that the Earth's Axis, tho'

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according to their Diſtance from the primary Planets, about which they revolve; the Terms *mean Diſtance* and *mean Motion* are applicable to all of them.

* The Earth's Velocity in its Orbit is indeed greater than what is above aſſigned, as appears by the Note, *Page* 47.

tho' it always preſerves the ſame Inclination to the Plane of the Ecliptic, yet deviates from its Parallelim, with a very ſlow retrogade Motion from Eaſt to Weſt, at the Rate of 50 Seconds in a Year, or one Degree in 72 Years; whereby it deſcribes a Circle, of 23½ Degrees Radius, round the Pole of the Ecliptic, and completes its Revolution in 25920 Years. Suppoſe a Circle to be drawn in the Heavens of 47 Degrees Diameter, round the North Pole of the Ecliptic as its Center. Let the Axis of the Earth be produced to that Circle; then the End of the Axis would move round in that Circle, and the Axis itſelf would deſcribe the Surface of a Cone, in one complete Revolution, whoſe Baſe is that heavenly Circle, and whoſe Vertex is at the Center of the Earth. Hence it follows, that all the fixed Stars in that imaginary Circle, will, in their Turns, be Pole-Stars to the Earth; and that which is now the Pole-Star, will, in Time, be 47 Degrees diſtant from the Pole. The Caſe is the ſame as to the South Pole; ſo that the Surfaces of two Cones are deſcribed, whoſe Vertexes meet at the Earth's Center.

Thoſe two Points in the Earth's Orbit, where the Sun is vertical to the Equator, are always the *Equinoctial Points:* But as the Earth's Axis deviates from its Parallelſm, thoſe Points in its Orbit muſt alſo change their Places. Suppoſe the Direction of the

Axis to be changed 90 Degrees; or that it now points to a fixed Star, in the imaginary Circle, 90 Degrees of the Circle diſtant from that which was formerly the Pole-Star: It is evident that the Equinoctial Points are *now*, where the ſolſticial Points were *then*; and that the *ſolſticial Points* are now moved into the former Places of the *equinoctial Points*. When the Axis has moved 180 Degrees, or thro' half the Circle, the *vernal Equinox* is got into the ancient Place of the *autumnal*, and the *Summer Solſtice* into the Place where the *Winter* was formerly. When the *former* of theſe two Caſes ſhall fall out, *viz.* when the Axis has moved 90 Degrees, the Summer and the Winter will be of the ſame Length; whereas there is now eight Days difference betwixt them: when the *latter* ſhall come to paſs, *viz.* when it has proceeded 180 Degrees, the Summer will be as much ſhorter than the Winter, as it is now longer; and the Sun will be furtheſt off from the Earth in our Winter, and neareſt to it in our Summer.

As this Motion of the equinoctial and ſolſticial Points is backwards, or from Eaſt to Weſt, contrary to the Order of the Signs of the *Zodiac*, the fixed Stars will appear to move the contrary Way; which they have done, ſince the Colures were firſt deſcribed, and the Aſteriſms drawn, by the ancient Aſtronomers, (about two Thouſand Years ago)

ago) about a whole Sign; ſo that the Stars, which were then in that Portion of the *Zodiac*, which they named *Aries*, are now got into *Taurus*; and thoſe that were then in *Taurus* are now in *Gemini*, &c. But tho' the Aſteriſms or Conſtellations, have thus apparently ſhifted their Places; we ſtill call the twelve Portions of the Zodiac by the ancient Names; *v. g.* we ſtill call that the firſt Point of *Aries*, where the vernal Equinox now happens, tho' it is gone back to the beginning of the Conſtellation *Piſces*; and call that the firſt Point of *Cancer*, where the Summer Solſtice now happens, though it is gone back to the Beginning of the Conſtellation *Gemini*.

From this Preceſſion of the Equinoxes ariſes the Difference betwixt the *Siderial* and the *Tropical* Year, which will be taken Notice of Part III. For when the Sun is exactly in one of the Tropics, ſuppoſe the Tropic of Cancer, the Earth is not yet arrived to the ſame Point of the Heavens where it was, when the Sun was in the ſame Tropic laſt Year, by 50 Seconds of a Degree; and it will take 20 Minutes of Time to run thro' thoſe 50 Seconds of a Degree, and to arrive at the ſame Star, or Point, in the Heavens, where it was at the laſt Summer Solſtice. Hence the Siderial Year exceeds the Tropical Year by 20 Minutes.

The phyſical Cauſe of this Preceſſion of the Equinoxes was unknown to all Aſtronomers, before the great Sir *Iſaac Newton*; who has diſcovered, that it ariſes from the oblate ſphæriodical Figure of the Earth *, which is occaſioned by its diurnal Rotation.

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CHAP. IV.

Of the MOON.

THE Moon, which, of all the heavenly Bodies next to the Sun, appears biggeſt and brighteſt, becauſe of her Nearneſs to the Earth, on which ſhe is a conſtant Attendant, is an opake Globe, which has no light of its own, but only reflects the Light of the Sun which ſhines upon it.

That the Moon ſhines only with a borrowed Light, may be concluded from her various Phaſes; for if ſhe were a luminous Body, like the Sun, ſhe would always ſhine with a full Orb, as the Sun does.

The Moon's mean Diſtance from the Earth is about 240,000 Miles. Its Diameter is 2175 Miles.

One Hemiſphere of the Moon is always

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* *i. e.* Its Diameter at the Equator is longer than from Pole to Pole; or its Shape is rather like an Orange than a Lemon, or a perfect Globe.

enlightened by the Sun, while the other Hemiſphere is in Darkneſs.

The Moon, beſides her being carried with the Earth round the Sun in a Year, has a double Motion of her own.

1. Round her own Axis in a Month.

2. Round the Earth, in her proper Orbit, in the ſame Time.

1. The Moon's Revolution on her own Axis, once in a Month, certainly appears by her keeping the ſame Face always towards the Earth.

In the Moon the Days and Nights are each a Fortnight long, and always nearly of the ſame Length.

2. Of the Moon's Motion round the Earth.

The Orbit in which the Moon moves round the Earth is an Ellipſis, having the Centre of the Earth in one Focus. That Point of her Orbit wherein ſhe is neareſt the Earth is called her *Perigeon*, or *Perigee*; the oppoſite Point, in which ſhe is furtheſt off from the Earth, is called her *Apogeon*, or *Apogee*: theſe two Points are alſo called her *Apſides*; the one, *viz.* the *Apogeon*, is the higher *Apſis*, the other the lower *.

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* The ſame Terms are applied to all other Planets. Any Planet is in its Apogeon, or higher Apſis, when it is furtheſt off from the Earth; and its Perigeon, or lower Apſis, when neareſt to it.

The Moon's Orbit is inclined to the Plane of the Ecliptic, making with it an Angle of about five Degrees.

The two Points where the Moon's Orbit coincides with the Plane of the Ecliptic, are called her *Nodes*.

The Node by which the Moon aſcends above the Plane of the Eliptic Northward, is called the *Dragon's-Head*, and is marked thus ☊. The oppoſite Node, by which ſhe deſcends below the Eliptic Southward is called the *Dragon's-Tail*, and is thus marked ☋.

An imaginary Line, carried croſs the Moon's Orbit, and reaching from Node to Node, is called *the Line of the Nodes*.

The Line of the Nodes appears continually to move in Antecedence, or contrary to the Order of the Signs of the Zodiac; and it revolves in nineteen Years.

The Moon can never appear exactly in the Ecliptic more than twice in her Period, *viz*. when ſhe is in the Nodes.

The Moon's diſtance from the Plane of the Ecliptic is called her *Latitude*; her greateſt Latitude is 5 Degrees 18 Minutes.

As the Sun appears to paſs thro' the twelve Signs of the Zodiac in a Year, ſo does the Moon in a Month.

When the Moon is in that Part of her Orbit which is neareſt the Sun, ſhe is ſaid to be in Conjunction with the Sun. Then the Whole of her enlightened Hemiſphere is turned from the Earth. Then it is *New Moon.*

When ſhe has proceeded thro' one eighth of her Orbit, a little Part of her enlightened Hemiſphere is turned towards the Earth, and ſhe appears *horned.*

When ſhe has advanced two eighths, ſhe enters on her firſt Quarter; then we ſee a *half Moon.* When ſhe has gained three eighths of her Orbit, ſhe appears *gibbous* or *bumped.*

When ſhe has proceeded thro' half her Orbit, the whole enlightened Hemiſphere is towards the Earth; then ſhe is ſaid to be *full,* and in Oppoſition to the Sun. The Sun and Moon are then ſeen in the oppoſite Parts of the Heaven, one riſing when the other ſets. When ſhe is advanced five eighths, ſhe is again *gibbous*; but whereas the Defect or darkened Part was before toward the Eaſt, it is now toward the Weſt.

When ſhe has reached three Quarters of her Orbit, ſhe enters on her laſt Quarter, and we ſee a *half Moon* again.

At ſeven eighths ſhe appears *horned.*

When ſhe has completed her Revolution, the whole enlightened Hemiſphere is again inviſible, and we have another *New Moon.*

N. B. The Moon moves in her Orbit at the Rate of about 2300 Miles an Hour.

The Moon performs a complete Revolution in her Orbit in the Space of 27 Days, and 7 Hours, which is called a *Periodical Month*; but the Earth having in that time advanced thro' almoſt a whole Sign in its annual Courſe, and carried the Moon along with it, the Moon will not come to the ſame Poſition, with reſpect to the Sun and Earth, as ſhe was in when ſhe began her Circle, until two Days afterwards. Thence it follows, that from New Moon to New Moon, which is called a *Synodical Month*, or *Lunation*, is 29 Days and a half, pretty nearly. Therefore, tho' in the Space of a Year the Moon performs 13 complete Revolutions round the Earth, or 13 periodical Months and 10 Days over; yet there are but 12 complete Lunations, or ſynodical Months, and 11 Days over, in a Year.

As the Moon, by reflecting the Light of the Sun, enlightens the Earth in the Night, ſo does the Earth much more enlighten that Hemiſphere of the Moon which is turned towards it; for the Surface of the Earth being above fifteen times bigger than that of the Moon, probably reflects more than fifteen times as much Light as the Moon does to the Earth. From hence ariſes that dim Light which is viſible in the darkened Part of the Moon a little before and after the Change. The Earth appears new and horned, gibbous and full to the Moon, juſt as the Moon does to the Earth, but fifteen times larger. When it is new Moon it is full Earth, and *vice verſâ*.

The Moon proceeds daily in her Orbit about 13 Degrees, and loſes about 48 Minutes a Day, one Day with another, in the time of her riſing; but yet ſhe loſes more when ſhe is in one Part of her Orbit, and leſs in another; which is occaſioned by the Moon's Path, (which, at preſent, we ſuppoſe to be the ſame as the Ecliptic) lying ſometimes more oblique to the Horizon than at others. Suppoſe the Moon is in the Beginning of Aries when ſhe riſes To-day; To-morrow, when the Beginning of Aries comes again to the Horizon, the Moon is got 13 Degrees further Eaſtward, and therefore does not riſe till ſometime after. Now when the Ecliptic is in its moſt perpendicular Poſition to the Horizon, at the Time of the Moon's riſing, 13 Degrees ſet her at a much greater Diſtance below the Horizon, than when it is in its moſt oblique Poſition; conſequently ſhe will be longer in coming to the Horizon in the former Caſe, than in the latter. When the Beginning of Libra cuts the Horizon in the Eaſt, the Ecliptic is then in its moſt perpendicular Poſition to the Horizon; but when the firſt Point of Aries touches it in the ſame Place, it is then in its moſt oblique Poſition. Conſequently when the Moon is at, or near, the Beginning of Aries, at the

Time of her Oppoſition to the Sun, or at full Moon, (which falls out about the autumnal Equinox,) there is then the leaſt Difference in the Time of her riſing from one Night to another, after the Full, that there is any Time of the Year. And if the Moon be at the ſame Time aſcending from South to North Latitude, that will reduce her Path nearer to a parallel Poſition to the Horizon, by about 5 Degrees, than if ſhe moved in the Ecliptic; and ſo make the Difference in the Time of her riſing to be ſtill leſs.

This full Moon is called the *Harveſt Moon*; and it is remarkable for its varying ſo little in the Time of its riſing for ſeveral Nights together, immediately after the Full.

If the full Moon happens juſt at the Equinox, or preſently after it, the Ecliptic becomes more perpendicular to the Horizon, at the Time of the Moon's riſing, every Day than other for many Days after; and ſo long ſhe loſes more and more in the Time of her riſing. But if the full Moon falls out before the Equinox, the Ecliptic grows more and more oblique to the Horizon at the Time of the Moon's riſing; and ſhe loſes leſs and leſs in the Time of her riſing every Day than other, till ſhe arrives at the firſt Point of *Aries*. Now as that Week in the Summer or Winter, in which the Sun riſes every Day neareſt to the ſame Time, does not begin at the *Solſtice*, but before it, and has the *ſolſticial Day* in the

Middle of it; ſo that Week in the Year, next after a full Moon, when ſhe riſes every Evening neareſt to the ſame Time, muſt begin not with the Moon's arriving at the firſt Point of *Aries*, (when the Ecliptic is in the moſt oblique Poſition of all to the Horizon at the Time of her riſing,) but two or three Days before. Therefore it is, generally, that the full Moon in *Auguſt*, when ſhe comes to her Oppoſition in *Piſces*, has moſt remarkably the Property of the *Harveſt Moon*. And the next full Moon after, *viz.* in *September*, which has the ſame Property of riſing nearly at the ſame Time, for ſeveral Nights after the Full, tho' not quite ſo remarkably as the former, is, by ſome, called the *Hunter's Moon*.

That the Surface of the Moon is very uneven and mountainous, is apparent from the Irregularity or Unevenneſs of the Line which ſeparates the enlightened from the dark Part of its Diſk, at any Time when the Moon is not *full*; which Line, when viewed with a Teleſcope, appears, as it were, toothed, and cut with innumerable irregular Notches. And, beſides, ſeveral ſhining Points may be ſeen in the dark Part of the Moon, quite ſeparated, tho' not far diſtant from the enlightened Part. Theſe are concluded to be the Tops of Mountains, which are ſooner reached by the Sun's Beams than the lower Parts, that lie about them. The bright Top of one of theſe lunar Mountains has been obſerved on the 4th

Day after the new Moon, to be diſtant from the Confines of the enlightened Surface about a 16th Part of the Moon's Diameter; from whence (ſuppoſing the true Meaſure of the Moon's Diameter to be known) it is eaſy to compute the Height of that Mountain; which is accordingly computed to be nine Miles high, that is, three times higher than the Top of any Mountain on the Earth.

Some Parts of the Moon's Surface, even when ſhe is full, appear of a duſkiſh Colour. Theſe are ſuppoſed, by ſome, to be Seas and Lakes. But Dr. *Keill* aſſerts (vid. *Aſtron. Lectures*, Lect. 10. "that when they are "looked at with a good Teleſcope, they "appear to conſiſt of an Infinity of Caverns "and empty Pits, whoſe Shadows fall with"in them; which can never be in a Sea, "or liquid Body. Theſe black Spots there"fore cannot poſſibly be Seas: but they "conſiſt of ſome darker and ſad coloured "Matter, which does not reflect the Light "ſo ſtrongly as the ſolid and ſhining Moun"tains do."

There ſeem to be no Clouds about the Moon: for when there are no Clouds in our Air, ſhe conſtantly appears to us with the ſame Luſtre.

CHAP. V.

Of the Eclipſes of the Sun and Moon.

AN Eclipſe of the Sun is occaſioned by the Moon's coming betwixt the Sun and the Earth, and thereby hiding the Light of the Sun from the Earth; which can only happen when the Moon is in Conjunction with the Sun, or at New-Moon.

An Eclipſe of the Moon is occaſioned by the Shadow of the Earth falling upon the Moon; or by the Moon's paſſing thro' the Shadow of the Earth, whereby ſhe is neceſſarily darkened, and loſes the Light of the Sun. This can only happen when the Moon is in Oppoſition to the Sun, or at Full-Moon.

The Reaſon why the Sun is not eclipſed every New-Moon, and the Moon every Time ſhe is full, is becauſe of the Inclination of the Moon's Orbit to the Plane of the Ecliptic; ſo that an Eclipſe can never happen, but when the Moon is either at or near one of the Nodes.

If the Moon happens to be exactly in the Node at the Time of her Conjunction, it occaſions a *central Eclipſe* of the Sun, which is commonly *total*; but ſometimes, as when the Earth is in its *Perihelion*, and the Moon in her *Apogee*, the Eclipſe will be *annular*; that is, a luminous Circle of the Sun will appear round the Body of the Moon.

If ſhe be near the Node, the Eclipſe may be *total*, tho' not *central*. If ſhe be any where within 12½ Degrees of the Node, ſhe will hide at leaſt ſome Part of the Sun from the Earth, and produce a *partial Eclipſe*. If ſhe be further from the Node than 12½ Degrees, there will be no Eclipſe at all; but the Light of the Sun will paſs to the Earth, either under or over the Moon, without Obſtruction.

So if the Moon be exactly in the Node at the Time of her Oppoſition, the Eclipſe of the Moon, by the Shadow of the Earth, will be *central* and *total*. If near the Node, *total*, tho' not *central*. If at a greater Diſtance, but within 16½ Degrees, the Shadow of the Earth will fall upon Part of the Moon, and occaſion a *partial* Eclipſe. But if at a greater Diſtance than 16½ Degrees, there will be no Eclipſe at all.

The Line of the Nodes being carried nearly parallel to itſelf, round the Sun in a Year, would twice in the Year, if produced, paſs thro' the Sun; and the New and Full Moons which happen neareſt to ſuch a Poſition of the Nodes will, moſt commonly, produce Eclipſes: So that there are ordinarily four Eclipſes in a Year, *viz.* two of the Sun, and two of the Moon; which fall out in Pairs, thus, one of each Luminary at a Fortnight's Diſtance, and another Pair, in the ſame manner, about half a Year after.

The Shadows which both the Earth and the Moon caſt behind them, which cauſe the Eclipſes, are of a conical Figure, terminating in a Point at a Diſtance from their Bodies; which is proved thus:

If the Shadow of the Earth were a Cylinder, or every where of the ſame width, (which muſt be the Caſe, if the Sun, and the Earth were of the ſame Bigneſs,) or if it grew wider and wider the further it extended, (which would be the Caſe, if the Earth were bigger than the Sun,) it would run out into infinite Space; and ſometimes it would involve in it, and eclipſe the Planets *Mars*, *Jupiter* and *Saturn*. But, as that never happens, we may reaſonably conclude, that the Shadow of the Earth is a Cone, whoſe Point, or Vertex, falls ſhort of any of thoſe Planets. Beſides, it is found that the Moon is longer in paſſing thro' the Earth's Shadow, when ſhe is in her Perigee, or nearer the Earth, than when ſhe is in her Apogee, or further off from it; which affords another Proof that the Shadow of the Earth is a Cone, which grows leſs the further it is extended; and conſequently this proves too that the Sun is bigger than the Earth.

If the Diameter of the Earth's Shadow, where it reaches the Moon, were not ſo long as the Diameter of the Moon, (as would be the Caſe if the Moon were bigger, or as big as the Earth,) the Moon could never be totally eclipſed by it. But ſince the Moon is often totally eclipſed by the Shadow of the Earth, ſhe muſt be leſs than the Earth, therefore much leſs than the Sun, and conſequently her Shadow muſt be alſo conical.

The Shadow of the Moon, where it reaches the Earth, is ſo ſmall, that but a little Part of the Earth can be covered by it at a Time; therefore a total Eclipſe of the Sun can laſt no longer, in one Place, than about four Minutes. But the Diameter of the Earth's Shadow, where the Moon paſſes thro' it, is three or four Times longer than the Diameter of the Moon's Body; therefore the Moon is ſometimes totally eclipſed for about three Hours together.

Since when the Moon is eclipſed, ſhe is really darkned, and loſes the Light of the Sun, from ſo much of her Diſk as is involved in the Shadow of the Earth, a lunar Eclipſe muſt appear juſt the ſame in all Parts of the World, where it is ſeen. But when the Sun appears eclipſed, he, in Reality, loſes none of his Light, only the Moon ſtands in the Way of our ſeeing him, either wholly or in part. And ſince the Moon can hide the Sun but from a little Part of the Earth at one Time, a ſolar Eclipſe will appear differently in different Places. In one Place it may

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may be central and total, the Moon being juſt between that Place and the Sun, or that Place being juſt in the Center of the Moon's Shadow; while the Moon hides but Part of the Sun from other Places; and from others, no part of him at all.

Thus in Fig. V. at all Places of the Earth between *y* and *y* the Sun is ſeen eclipſed, either totally or partially; between *o* and *o* the Eclipſe is total; between *e* and *e* it is annular; at *u* the Sun appears half darkened; but in Parts more remote from the Center of the Shadow than *y*, there is no Eclipſe at all.

A lunar Eclipſe ſeen from the Moon, is an Eclipſe of the Sun.

If a ſolar Eclipſe (which is more properly an Eclipſe of the Earth can be ſeen from the Moon, it appears only as a dark Spot paſſing over the Diſk of the Earth.

It is obſerved that the Moon, even when ſhe is totally eclipſed, or wholly involved in the Shadow of the Earth, does not loſe all her Light, but ſtill appears of a faint duſky red Colour; which is owing to the Sun's Rays being refracted, or bent inwards, in paſſing thro' the Earth's Atmoſphere, (juſt as they are in paſſing through a Burning-glaſs,) by which Means they enter, and, in ſome Meaſure, enlighten the conical Shadow of the Earth, where it involves the Moon; and it is by that faint Light that the Moon is ſtill viſible, even in the midſt of a central Eclipſe.

Aſtro-

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Aſtronomers divide the Diameters both of the Sun and Moon into twelve equal Parts, which they call *Digits*, and each Digit into Minutes, *&c.* by which they meaſure the Quantity of Obſcuration, or the Bigneſs of an Eclipſe.

COROLLARIES.

1. The Shadow of the Earth, which is viſible upon the Moon in a lunar Eclipſe, appearing always circular, is a ſenſible Demonſtration of the globular Form of the Earth.

2. Since the Bigneſs of an Eclipſe depends on the Bigneſs of the Shadow that falls on the eclipſed Body, and That on the Bigneſs, and Diſtance of the Body which caſts the Shadow; and as the Time of an Eclipſe depends on the Motions of thoſe Bodies, it is evident that an Eclipſe could not be computed before it happened, unleſs all theſe were known. But certain it is, that Aſtronomers are able to compute * Eclipſes beforehand, to almoſt a Minute of Time; therefore we muſt conclude, that their Knowledge of theſe Matters is very conſiderable and certain.

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* The Computation of Eclipſes requires a great deal more previous mathematical Knowledge than the Perſons, for whoſe Service this Treatiſe is deſigned, are ſuppoſed to be furniſhed with; therefore I wholly omit it. Thoſe that would acquaint themſelves with the Method of computing Eclipſes, both ſolar and lunar, may ſee it in Dr. *Gregory*'s or Dr. *Keill*'s Aſtronomy. And they may find good Tables for calculating Eclipſes in *Duntborne's Practical Aſtronomy of the Moon.*

CHAP. VI.

The Doctrine of the Tides.

THE Surface of the whole Globe (as alſo its internal Parts) is every where preſſed by Gravitation towards its Center.

If the Globe were all fluid, and ſome Parts of the Surface were more preſſed than others, the Parts that were moſt preſſed would be loweſt, or neareſt the Center; and the Parts leaſt preſſed would be the higheſt, or furtheſt from the Center.

Both Sun and Moon attract the Earth with Forces which pervade the whole Globe; but which are *greater* or *leſs* in the different Parts of it, as thoſe Parts are nearer to or further from thoſe Luminaries, and the Moon by Reaſon of her being ſo much nearer to the Earth than the Sun, has the greateſt Influence: and cauſes the greateſt Alteration in the Figure of the Earth or raiſing the Tides *.

The Effects of the Moon's Attraction upon the Fluids of the Globe, to alter their natural ſpherical Figure, muſt be as follows:

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* The Reader, may ſee this Matter fully explained in *Maclaurin*'s Account of *Sir Iſaac Newton*'s Philoſph. Diſcoveries, *B.* 4. *Ch.* 7.

Firſt, Upon the Hemiſphere towards the Moon; where the middle Point being neareſt the Moon, and therefore moſt attracted by her, (directly contrary to its natural Gravitation towards the Center) is leſs preſſed by Gravitation than any other Part of the Surface of that Hemiſphere, and conſequently the Waters will there riſe higheſt.

Secondly, Upon the Hemiſphere that is remote from the Moon; where the middle Point being leaſt attracted by the Moon, (by reaſon of its greateſt Diſtance from her) is left behind, while all the other Parts and even the Center itſelf, are more attracted towards her: from whence it will follow, that the Surface of the Water at the Middle of that Hemiſphere, will be higher, or more remote from the Center, than in any other Part. The two middle Points will therefore be the higheſt in their reſpective Hemiſpheres; the one being really *more elevated*, the other *leſs depreſſed*, by the Moon's Attraction, than the adjacent Parts: So that theſe two Points may now be conceived of as the Summits of two oppoſite Mountains of Water, or the whole Globe may be conceived as now thrown into a ſpheroidical or oval Figure, whoſe longer Axis produced would paſs thro' the Moon. And by reaſon of the Earth's Rotation, theſe Mountains muſt be continually ſhifting their Places all round the Surface of the Globe; from whence there will follow two *Flood-Tides* and two *Ebb-Tides* in the Space of 25 Hours; in which Time the Moon moves from the Meridian of any Place, to the ſame Meridian again.

When the Sun and Moon are in Conjunction, or Oppoſition, that is at New or Full Moon, the Attraction of both theſe Bodies acting upon the Earth in the ſame Direction or in the ſame right Line, their Force is united to elevate the Waters; whereby are produced *Spring-Tides*.

When the Moon is in her Quadratures, her Attraction acts in one Direction, the Sun's in a quite contrary; by which Means they correct or counteract one another, the Moon raiſing the Waters where the Sun depreſſes them, and vice verſâ; which produces *Neap-Tides*.

It is evident, that if the two oppoſite Protuberances, or Summits of the two Mountains of Water, were always exactly at the Poles of the Earth, there would be no riſing and falling of the Waters by Means of the Earth's Rotation, or no Tides at all; but it would conſtantly be high Water at the Poles, and low Water all round the Equator. On the other Hand, when theſe two Summits are fartheſt from the Poles, that is, upon the Equator, the Riſe and Fall of the Waters, by Means of the Earth's Rotation, is then greateſt: therefore the nearer they are to the Equator, the Riſe and Fall is the greater:

and

and the nearer to the Poles, the Riſe and Fall is the leſs. Conſequently when the Sun and Moon are in Conjunction or Oppoſition, in or near the Equinoctial, as in *March* and *September*, the *Spring-Tides* muſt riſe higher, (the Summits of the two Mountains being then upon the Equator) than when they are in Conjunction or Oppoſition in the Tropics, as in *June* and *December*. And the Moon being in the Tropics at her Quadratures in *March* and *September*, and in the Equinoctial at her Quadratures in *June* and *December*, the *Neap-Tides* will be leſs vigorous in the former Months, and more vigorous in the latter. And, beſides, when the Moon is in the Tropics at her Quadratures the Sun is in the Equinoctial; therefore the Riſe and Fall of the Waters by his Influence (counteracting that of the Moon) is then greateſt, tho' ſtill leſs than that of the Moon, conſequently the *Neap-Tides* will then be weakeſt. But when the Moon is in the Equinoctial at her Quadratures, the Sun is in the Tropic, whoſe Influence, as counteracting the Moon, is then leaſt; therefore the *Neap-Tides* will then be ſtrongeſt. So that the Difference betwixt the *Spring* and the *Neap-Tides* is much leſs conſiderable at the *ſolſticial*, than at the *equinoctial* Seaſons.

Yet the higheſt Tides of the Year are obſerved to be *(cæteris paribus)* ſome time before the vernal, and ſome time after the autumnal

tumnal Equinox, *viz.* in *February* and *October*; which is owing to the Sun's being nearer the Earth in the Winter Months, when, conſequently, the Force of his Attraction on the Waters is greater, than in the Summer Months.

It has further been obſerved, that, in this Part of the World, the Tides riſe higher when the Moon is in the Northern Signs, at the Time of her coming to the Meridian, above our Horizon; and when ſhe is in the Southern Signs at the Time of her coming to the Meridian, below the Horizon; than when, on the contrary, ſhe is in the Southern Signs above our Horizon, and in the Northern Signs below it. The Reaſon of which will evidently appear upon the Globe, *viz.* That in the two former Caſes, the Moon is nearer to our Zenith and Nadir, when ſhe is upon our Meridian, or at the Time of high Water, and, conſequently, we are then nearer to the Summits of the Mountains of Water, than in the two latter Caſes.

Though the Force by which the Tides are raiſed is continually increaſing, from the Time of the Moon's Quadrature to her Conjunction or Oppoſition, after which it gradually decreaſes until the next Quadrature; yet the higheſt Spring-Tide is not juſt at the New or Full Moon, but a Day or two after; which may be thus accounted for.

Conceive every Tide as raiſed by a double Force, *viz.* ſome Part of the Force by which the laſt Tide was raiſed ſtill remaining, and the Force of a new Impulſe. When both theſe together amount to more than the whole Force which raiſed the laſt Tide, the preſent Tide muſt riſe higher than the laſt did. Suppoſe the remaining Force to be always half the whole Force of the laſt Tide: Suppoſe the new Impulſe, juſt at New or Full Moon, to be 15, and the whole Force, with which that Tide is raiſed to be 22. Let the new Impulſe of the new Tide be but 14, then 14+11 (*i. e.* half 22)=25: this Tide will therefore riſe higher than the laſt. Let the new Impulſe of the next Tide be but 13; then 13+12½ (*i.e.* half 25) =25½. Conſequently this Tide will riſe ſtill higher than the laſt did; tho' the Force of the Action of the two Luminaries, by which the Tides are raiſed, is now conſiderably abated.

For the ſame Reaſon, the deadeſt Neap-Tides will fall out, not preciſely at the Moon's Quarters, but ſometime after.

CHAP. VII.

Of the Planets Mercury, Venus, Mars, Jupiter, *and* Saturn.

THE Planets are diſtinguiſhed into *Inferior* and *Superior*. Mercury and Venus are called the *Inferior* Planets, becauſe they are lower than the Earth, in the ſolar Syſtem, and nearer to the Sun; Mars, Jupiter, and Saturn, are called the *Superior Planets*, becauſe they are higher than the Earth, and more remote from the Sun.

MERCURY revolves about the Sun in 87 Days 23 Hours, at the mean Diſtance of 32,000,000 Miles. As this Planet is almoſt three times nearer the Sun than the Earth is, his Light and Heat is ſeven times greater than ours*; which Degree of Heat is ſufficient to make Water boil.

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* The Quantity of Light and Heat which the ſeveral Planets receive from the Sun, is reciprocally as the Squares of their Diſtance.

N. B. No Regard is here had to Atmoſpheres, or other Circumſtances that may be peculiar to the ſeveral Planets, and which may poſſibly increaſe or diminiſh their Light or Heat, but merely to their Diſtances from the Sun.

This Planet muſt therefore conſiſt of denſer Matter than the Earth; and if it be inhabited, it muſt be by other ſort of Creatures than any that live here.

An Eye in Mercury ſees five Planets ſuperior to it. Venus and the Earth, when they are in Oppoſition to the Sun, ſhine upon Mercury with a full Orb, and afford a conſiderable Light to this Planet in the Night; but the other Planets do not afford him ſo much Light as they do to us.

It is not known whether Mercury revolves on his Axis, nor what is the Inclination of his Axis to the Plane of his Orbit; conſequently the Length of his Days, and what Change of Seaſons this Planet is ſubject to, are both unknown; only the Orbit of Mercury, being the moſt excentric of any of the Planets, muſt occaſion a conſiderable Alteration of his Light and Heat, in different Times of his Year.

Mercury's greateſt *Elongation*, or apparent Diſtance from the Sun, is about 28 Degrees. The Inclination of his Orbit to the Plane of the Ecliptic is 6 Degrees, 54 Minutes.

There may be other Planets betwixt Mercury and the Sun; but if there are, they can never be ſeen by us, becauſe of their Nearneſs to the Sun.

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VENUS, the brighteſt of the primary Planets, and neareſt to the Earth, is 7906 Miles Diameter. She revolves on her Axis in 23 Hours * and in her Orbit round the Sun in 224 Days, 16 Hours, 46 Minutes at the mean Diſtance of 59,000,000 Miles from the Sun. Her Light and Heat is more than twice as much as ours. The Orbit of Venus being nearer the Sun than the Earth's annual Orbit, ſhe is much nearer the Earth, *viz.* ſix times nearer, at her *inferior Conjunction*, or when ſhe is betwixt the Earth and the Sun, than at her *ſuperior Conjunction*, *viz.* when the Sun is betwixt the Earth and Venus; therefore ſhe appears much larger to us at one time than another.

Her greateſt *Elongation* is about 48 Degrees. The Inclination of her Orbit to the Plane of the Ecliptic is 3 Deg. 24 Min.

She appears with different Phaſes, *viz.* *horned* and *full* like the Moon; and ſometimes, at her inferior Conjunction, ſhe appears as a Spot paſſing over the Body of the Sun.

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* That is, according to *Caſſini*'s Obſervations, which he made in the Years 1666 and 1667. But *Sig. Francis Bianchini* has advanced a new Theory of Venus, according to which ſhe performs her Revolution on her Axis in about 24 Days and 8 Hours; and the Inclination of her Axis to the Plane of her Orbit is 15 Degrees. He grounds this Theory on Obſervations which he made on that Planet in the Years 1726 and 1727, and has publiſhed it under the Title of *Heſperi et Phoſphori nova Phænomena*. But I do not find it has yet been confirmed by the Obſervations of other Aſtronomers.

The different Phaſes of Venus were firſt diſcovered by the great Italian Philoſopher *Galileo*, in the Beginning of the laſt Century: whereby he fulfilled the famous Prophecy of *Copernicus*; who, when it was objected to his Hypotheſis, that according to it, *Venus ought to undergo the ſame Changes and Phaſes that the Moon does*, anſwered, that *perhaps the Aſtronomers in after Ages would find, that Venus does really undergo all theſe Changes.*

The inferior Planets, from the Time of their ſuperior to the Time of their inferior Conjunction, are ſeen more *eaſterly* than the Sun, and ſet *after* him. Then they are *Evening Stars.*

But from the Time of their inferior to their ſuperior Conjunction, they are ſeen *weſtward* of the Sun; and conſequently ſet in the Evening, and riſe in the Morning *before* him. Then they are *Morning Stars.*

They are ſeen from the Earth to move much ſwifter in their Orbits round the Sun, at ſometimes than at others; and their Motion at ſometimes appears to be *direct*, or according to the natural Order of the Signs of the Zodiac, as from *Aries* to *Taurus*, *&c.* ſometimes *retrograde*, or contrary to the Order of the Signs, as from *Taurus* to *Aries*,

&c.

&c. and ſometimes they appear to be *ſtationary*, or without any Motion at all, for ſome Days together; all which is occaſioned by the Earth and theſe Planets moving in concentric Orbits, one within another, but with different Volocities.

Let the leſſer Circle about the Sun repreſent the Orbit of Mercury, and the larger the Earth's annual Orbit, about a Quarter, or 12 Weeks of which, anſwers, in time, to Mercury's Year. When the Earth is at 0, and Mercury at 0, in his Orbit, he appears at 0 in the Zodiac; about a Week after at 1 1 1, he appears *direct*; at 2 2 2 and 3 3 3 he continues *direct*, though more ſlow in his Motion; at 4 4 4 he is *ſtationary*; at 5 5 5 he appears *retrograde*, as alſo at 6 6 6 (when he is in his inferior Conjunction;) and at 7 7 7, till about 8 8 8, he is *ſtationary* again; after which, at 9 9 9 and 10 10 10, he becomes *direct* again; and more ſwiftly at 11 11 11 and 12 12 12. The Caſe of Venus is much the ſame. Fig. VI.

MARS, who looks the moſt red and fiery of any of the Planets, revolves on his Axis in 24 Hours, 40 Minutes, at the mean Diſtance of 123,000,000 Miles from the Sun. His Days and Nights are always nearly of the ſame Length; becauſe his Axis is nearly at right Angles to the Plane of his Orbit. The Inclination of his Orbit, to the Plane of the Ecliptic, is 1 Degree 52 Minutes. His Year is almoſt twice as long as ours, (for he performs his Revolution about the Sun in 1 Year, 321 Days, 23 Hours) but with little Variety of Seaſons. The Quantity of Light and Heat which this Planet receives from the Sun is not half ſo much as ours. Mars ſeems to have an *Atmoſphere* round him, as the Earth has, which is argued from the fixed Stars appearing obſcure, when they are ſeen juſt by his Body.

This Planet is five times nearer to us when he is in Oppoſition to the Sun, than when he is in Conjunction with him; therefore he appears ſo much bigger and brighter at one time than another.

A Spectator in *Mars* will hardly ever ſee *Mercury*; unleſs ſometimes as a Spot in the Diſk of the Sun. To an Eye in Mars, *Venus* will appear about as far from the Sun, as *Mercury* does to us. And the *Earth* about as far off as Venus appears to us.

JUPITER's mean Diſtance from the Sun is 424,000,000 Miles. He revolves on his Axis in 10 Hours; and his Days and Nights, each of 5 Hours, are always nearly of the ſame Length, all over his Surface; becauſe his Axis, like that of Mars, is nearly at right Angles to the Plane

Earth in Perihelion

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of his Orbit. The Inclination of his Orbit, to the Plane of the Ecliptic, is 1 Deg. 20 Min. His Year is equal to almoſt 12 of ours, *viz.* to 11 Years, 314 Days, 12 Hours, but without any conſiderable Change of Seaſons. The Light and Heat which this Planet receives from the Sun is but one 27th Part of what the Earth enjoys.

Beſides abundance of Spots which may be ſeen on Jupiter's Surface, he appears to be ſurrounded with ſeveral *Belts*, or *Girdles*, which are parallel to his Equator, and to one another; and are variable both in reſpect to their Breadth, and their relative Diſtances. Sometimes they appear wider, ſometimes narrower, ſometimes they are nearer, and ſometimes farther off from one another. Whether theſe Spots and Belts are inherent in the Body of the Planet; or whether they ſwim, like Clouds and Vapours, in its Atmoſphere, no Obſervations yet made are ſufficient to inform us.

This Planet has four other primary Planets beneath him; but they are all too near the Sun to be ever ſeen in Jupiter by an Eye of no ſharper Sight than ours: even Mars, which is furtheſt off from the Sun of all the four, will never be above 18 Degrees from him. And conſidering how ſmall a Planet Mars is, and how weakly he reflects the Sun's Light, he will ſcarcely be ſeen at ſo ſmall a Diſtance from the Sun: ſo that Saturn is the only primary Planet that can be ſeen in Jupiter.

Jupiter has four Satellites or Moons revolving about him, *viz.*

		D : H : M		Miles.
Firſt	Revolves in	1 : 18 : 28	at the Diſtance of	130,000
Second		3 : 13 : 14		364,000
Third		7 : 3 : 43		580,000
Fourth		16 : 16 : 32		1,000,000

His outermoſt Moon muſt appear almoſt as large to an Inhabitant of Jupiter (ſuppoſing his Eyes like ours) as our Moon does to us; and if the other Satellites are not leſs than the outermoſt, they muſt appear much larger. Mr. *Hugens* conceives them to be not much, if at all, leſs than the Earth. In Jupiter they have frequent Eclipſes of the Sun, and of their Moons; and ſometimes one Moon eclipſes another.

All the four Satellites of Jupiter were firſt diſcovered by *Galileo, Jan.* 7, 1610.

SATURN's mean Diſtance from the Sun is 777,000,000 Miles, his Year is equal to near 30 of ours, *viz* 29 Years, 167 Days, 22 Hours. The Inclination of his Orbit, to the Plane of the Ecliptic, is 2 Deg. 20 Min. Whether Saturn revolves on his

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Axis is not known: it is certain he enjoys but one 90th Part of the Light and Heat from the Sun that we do. An Eye in Saturn ſees no primary Planet but Jupiter, which always appears to accompany the Sun.

Saturn has five Satellites moving round him, *viz.*

	Revolves in	D : H : M	at the Diſtance of	Miles.
Firſt		1 : 21 : 19		146,000
Second		2 : 17 : 41		187,000
Third		4 : 13 : 47		263,000
Fourth		15 : 22 : 41		600,000
Fifth		79 : 22 : 4		1,800,000

The fourth Satellite is the largeſt of them all; the great diſproportionate Space betwixt that and the fifth, gives Room to conjecture that there may be a ſixth, tho' we have not yet diſcovered it.

The fourth Satellite was firſt diſcovered by the famous *Chriſt. Hugens*, in the Beginning of the Year 1665. The other four were all diſcovered by Mr. *Caſſini*, betwixt the Years 1671 and 1684.

Saturn has a vaſt ſolid Ring, different from all the other Planets, which encompaſſes his Body, as an Horizon does a Globe; it is about 21,000 Miles broad, and as much diſtant from Saturn's Body. The Thickneſs of it is to us almoſt inviſible;

ble; perhaps it may be 500 or 1000 Miles. This Ring caſts a vaſt Shadow upon the Body of the Planet, and it muſt occaſion very ſtrange, and different celeſtial Appearances to the Saturnian Inhabitants, if any ſuch there be.

The ſuperior Planets, as well as the inferior, are, by Turns, Morning and Evening Stars; and they appear *direct*, *ſtationary*, and *retrograde*.

Let the leſſer Circle about the Sun represent the Orbit of the Earth, and Fig. VII. the larger that of Jupiter, who moves through but about a 12th Part of his Orbit, while the Earth makes a complete Revolution round the Sun. When the Earth is at 0, and Jupiter at 0 in his Orbit, he is ſeen at 0 in the Zodiac; about a Month after at 1 1 1, he appears *direct*, and near his Conjunction with the Sun; at 2 2 2 and 3 3 3 he continues *direct*, tho' more ſlow in his Motion; about 4 4 4 he is *ſtationary*; at 5 5 5 he appears *retrograde*; as alſo at 6 6 6 (when he is in his Oppoſition) and at 7 7 7, till about 8 8 8 he is *ſtationary* again; after which, at 9 9 9 and 10 10 10 he becomes direct again; and more ſwiftly at 11 11 11 and 12 12 12. The Caſe of Saturn and Mars are much the ſame.

As the Orbits of all the Planets are inclined to the Plane of the Ecliptic, ſome

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more and ſome leſs, they all have Latitude; that is, they are always at ſome Diſtance from the Plane of the Ecliptic, except when they are juſt in the *Nodes* of their Orbits. Their Latitude, as it would appear to an Eye placed in the Sun, is called their *Heliocentric* Latitude; as it is ſeen from the Earth it is called their *Geocentric* Latitude. Now, tho' the greateſt *Heliocentric* Latitude of any Planet is but juſt equal to the Inclination of its Orbit to the Plane of the Ecliptic, yet its *Geocentric* Latitude may be much greater. For Inſtance, the greateſt Heliocentric Latitude of Venus is about 3½ Degrees; but as ſhe is much nearer the Earth, at one Time than another, ſhe will appear under a greater Angle with the Plane of the Ecliptic; or a Line drawn from the Obſerver's Eye to Venus, will make a greater Angle with the Plane of the Ecliptic at one Time than another, that is, when ſhe is nearer than when ſhe is farther off: and conſequently tho' her Heliocentric Latitude were exactly the ſame in both Caſes, yet her Geocentric Latitude would be very different. And thus it is, that Venus has at ſome Times, *viz.* when ſhe is neareſt the Earth and Retrograde, more than 8 Degrees Latitude; and it is on this Account the Zodiac is made to extend ſomewhat above 8 Degrees, on each Side of the Ecliptic, that it may be broad enough to take in the apparent Paths of all the Planets.

COROLLARY.

The *ſuperior Planets* appearing *direct*, *ſtationary*, and *retrograde*, is a proof of the Earth's annual Motion round the Sun; for if it had no ſuch Motion, they never could appear otherwiſe than *direct*.

That all the Planets, both primary and ſecondary, may be habitable Worlds, is a Notion, (however laughed at by the Vulgar, yet) not without a reaſonable Probability. For who that has ſeen any Engine, a *Wind-mill* for Inſtance, in his own Country, and knows the Uſe of it is to grind Corn; if he travels into another Country, and there ſees an Engine of the ſame ſort, will not reaſonably conclude that it is deſigned for the ſame Purpoſe? So when we know that the Uſe of this Planet, the Earth, is for an Habitation of various Sorts of Animals; and we ſee other Planets at a Diſtance from us, ſome bigger, and ſome leſs than the Earth, all of them ſolid Bodies, much of the ſame Shape with the Earth; one, at leaſt, encompaſſed with an Atmoſphere as the Earth is; all moving periodically round the Sun; moſt, if not all, of them revolving on their own Axis, juſt as the Earth does; and ſome of them attended with Moons, to enlighten them in the Night: is it not highly reaſonable to conclude, that they are all deſigned for the ſame Uſe that the Earth is, and that they are *habitable Worlds*, like this in which we live?

What Uſe can we conceive of Jupiter's and Saturn's Moons, which are not viſible to us without the Help of Teleſcopes, unleſs they are to enlighten thoſe Planets in the Night? And of what Uſe can their Light be to thoſe Planets, if there be no Inhabitants to enjoy the Benefit of it? Nay, of how little Uſe are any even of the primary Planets to our World? How little is the Light which they afford us? And as for any Influence upon us and our World, which the *Aſtrologers* aſcribe to them, which they conceit to be different, according to their different *Aſpects* *, and by which they pretend to foretel future Events;

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* *Aſpects* of the heavenly Bodies, ſignify their Situation in the Zodiac, with reſpect to one another; or their Diſtance from one another in Longitude. The Names and Characters of the Different Aſpects are,

1. ⚹ *Sextile*, when they are two Signs, or 60 Degrees from one another.

2. □ *Quartile*, when they are three Signs, or 90 Degrees diſtant.

3. △ *Trine*, when they are four Signs, or 120 Degrees diſtant.

4. ☍ *Oppoſition*, when they are ſix Signs, or 180 Degrees diſtant.

it is moſt certainly all a groundleſs and fooliſh Conceit. Whoever conſiders the vaſt Digance of the Planets from us, and that their *Aſpects* are according to natural laws, will not eaſily believe they can have any ſuch Influence at all.

CHAP. VIII.

Of COMETS.

COMETS, or Blazing-Stars, were anciently ſuppoſed to be Meteors, or Exhalations, ſet on Fire in the higheſt Region of the Air; but the Modern Aſtronomers have found that they are above the Orbit of the Moon. Moſt probably they are a Sort of excentrical Planets, which move periodically round the Sun.

5. ☌ *Conjunction*, when they are in the ſame Sign and Degree.

N. B. Two Bodies are ſaid to be in Conjunction when both are upon the ſame Line of Longitude, tho' they may not be in the ſame Point of the Heavens; but ſeveral Degrees Diſtant from each other in reſpect of Latitude. Thus Mercury and the Moon may be in Conjunction, when yet they are 12 Degrees aſunder; that is, when the former has near 7 Degrees of Latitude on one Side of the Ecliptic, and the latter above 5 Degrees Latitude on the other Side.

Their Orbits are very long Ellipſes, hav- the Sun in one *Focus* *.

The proper Motion of Comets is not the ſame in all, but each has its peculiar Courſe. Some go from Weſt to Eaſt, others from Eaſt to Weſt; ſome from North to South, others again from South to North, in all Planes and Directions: ſo that they are not, as the Planets are, contained within the Zodiac.

Not many more than twenty Comets have yet been obſerved; at leaſt ſo as that their Paths in the Heavens have been traced and deſcribed. The Time in which they complete their Revolution is not yet known, except perhaps of two or three of them.

When the Comets deſcend near to the Sun, they become viſible, and continue ſo for ſome time while they are aſcending again from him: but as they remove further off, we loſe Sight of them by Degrees; 'till at length they run out into far diſtant Regions, where they are quite inviſible to us, in by far the greater Part of their Orbits.

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* Mr. *Axout*, a French Gentleman, was the firſt, that I can find, who pretended to predict the future Motion of a Comet; which he did upon obſerving the Path of one that appeared *Jan.* 166$\frac{4}{5}$, and of another that appeared the Year following. But our great and famous Sir *Iſaac Newton* has ſince cleared up the Doctrine, and the Phænomena of the Comets, far beyond all that went before him, in his excellent *Princ. Philoſ. Mathem.* Lib. 3. Prop. 39. &c.

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When a Comet deſcends near to the Sun it is ſet on Fire; and its Tail ſeems to be nothing elſe but a long and very thin Smoke, or Train of Vapours ſtreaming from it, which always points to the Region oppoſite to the Sun.

The popular Diviſion of Comets into three Kinds, *viz.* *Cauduti* or *tailed*, *Barbati* or *bearded*, and *Criniti* or *hairy*, ariſes not from any real Difference of Comets from one another, but from different Circumſtances of the ſame Comet. For inſtance,

When a Comet is moving towards the Sun, the Train of Vapours follows it, like a *Tail*.

When it is moving from the Sun, after its Perihelion, the luminous Vapour marches before it, in the Manner of a *Beard*.

When the Vapour is projected directly behind the Comet from us, it is then hid from our View, excepting that we ſee a little of it appearing round the Comet, like a Border of *Hair*. This Appearance may be accounted for, partly, from the Train of Vapours widening as it recedes from the Head, (as it always does) ſo that we ſee a little of the remoter Part round the Body of the Comet; and partly, becauſe the Vapour is raiſed, by the Heat of the Sun, chiefly from the Side or Hemiſphere which is towards the Sun, and is thrown off, by Gravitation, the contrary Way. For as in our Air, the Smoke of a heated Body aſcends from the Earth, towards which the Body gravitates; ſo in the Heavens, where all Bodies gravitate towards the Sun, Smoke or Vapour muſt aſcend from the Sun; therefore the Vapour which is raiſed from that Side of a Comet which is towards the Sun, is turned back again, and thrown the contrary Way. Conſequently when the Comet is oppoſite to the Sun, and the heated Side is towards us, the Vapour, in returning back, is ſeen round the Edge of the Diſk of the Comet, and helps to form what is vulgarly called the *Hair*.

N. B. The *Tail* or *Beard* of a Comet appears longer or ſhorter, not only as it is really projected to a further or leſs Diſtance from the Head, but as it appears to us making a greater or leſs Angle, with a Line drawn from our Eye to the Comet. When we ſee it at right Angles, or any great Angle, it appears long; but if at a ſmall Angle it appears ſhort.

Sir *Iſaac Newton* has computed that the great Comet, which appeared 1680 and 1681, was heated, by its near Approach to the Sun, to the Degree of near 2000 Times the Heat of red hot Iron.

Bodies that can endure ſo intenſe a Heat, without being entirely diſſipated and deſtroyed, muſt needs be very hard and ſolid; ſuch therefore, no doubt, the Comets are.

Helvetius, by meaſuring the Comet that appeared 1665, found its Diameter to be three times as long as that of the Earth; conſequently the Body of that Comet muſt be twenty-ſeven times greater than the Earth *.

The Comet which appeared 1759, is ſuppoſed to be the ſame that appeared 1682, and before in 1607 and 1531; whoſe Period muſt therefore be 75 or 76 Years; and whoſe Return may be expected 1835 or 1836. Its greateſt Diſtance from the Sun, to its leaſt, is as 60 to 1: and its greateſt Light and Heat, to its leaſt, as about 3600 to 1.

The Comet which appeared 1661, is ſuppoſed to be the ſame that appeared 1532, whoſe Period is therefore about 126 Years. It may be expected again 1789. Its greateſt Diſtance to its leaſt, is computed to be more than 100 to 1, and its greateſt Light and Heat to its leaſt, more than 10,000 to 1.

The great Comet which appeared 1680 and 1681, is ſuppoſed to be the ſame that appeared in the 44th Year before the Chriſtian Æra, and again A. D. 531 or 532, again 1106, and laſtly 1680; therefore the Time of its Revolution muſt be 576 Years, and its next Appearance may be expected in the Year 2256. Its greateſt Diſtance to its leaſt is above 20,000 to 1, and its greateſt Light and Heat to its leaſt above 400,000,000 to 1.

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* Spheres are to one another as the Cubes of their Diameters.

We know but little, or rather nothing certainly, of the Uſe of Comets. They ſeem, in their preſent State, to be very unfit for the Habitation of Animals; becauſe of their intenſe Heat, when they are in one Part of their Orbit, *viz.* neareſt the Sun, and their extreme Cold in the oppoſite Part. But yet God could, no doubt, make Creatures who ſhould be capable of enduring both theſe Extremes. To imagine that the appearing of a Comet is ominous, and that it forebodes ſome approaching Calamity to any Part of the Earth, is a ſuperſtitious Conceit, without any Foundation in Reaſon; and it ſeems to be condemned in Scripture. *Jerem.* x. 2. *Thus ſaith the Lord, learn not the Way of the Heathen, and be not diſmayed at the Signs of the Heaven; for the Heathen are diſmayed at them.*

CHAP. IX.

Of the Equation of TIME.

AS the Moon wants two Days, over and above an entire Revolution in her Orbit, to complete a Synodical Month, or Lunation; (*vid.* Ch. iv. p. 68.) ſo, for the ſame Reaſon, does the Earth want about four Minutes, more or leſs, over and above an entire Revolution on its Axis, to complete a natural Day from Noon to Noon. Or thus: the Earth completes its Revolution in 23 Hours, 56 Minutes; but the Meridian on which it was Noon ſo long ago, is not yet come to Noon again; becauſe, ſince then, the Earth has advanced forward, in its annual Orbit, about one Degree; and therefore we muſt wait ſome time longer, before the Sun will come again upon the ſame Meridian, and make Noon. But now *that* Meridian will at ſometimes gain Noon again ſooner, after a complete Revolution, than at other Times; ſometimes in leſs than 4 Minutes, ſometimes in more; becauſe the Angle from the Sun to the two Points in the Earth's Orbit, the one where it was Yeſterday

day at Noon, the other where it is To-day, when it has completed its Revolution, is leſs in Summer, when the Sun is farther off from the Earth, than in Winter, when he is nearer to it: and conſequently, that Meridian will have the Sun upon it again ſooner, after the diurnal Revolution is completed, when the Angle is leſs, than when it is greater; therefore the natural Days from Noon to Noon are not of equal Lengths, which is one Reaſon of the Difference betwixt *equal Time*, which is meaſured by a Clock that is ſuppoſed to go without any Variation, and to meaſure exactly 24 Hours from Noon to Noon; and *apparent Time*, which is meaſured by the apparent Motion of the Sun in the Heavens, or by a good Sun-Dial.

Let A *a* C *c* F be the Earth's Orbit, S the Place of the Sun, A *a* = C *c* the Arch which the Earth runs over, while it makes a complete Revolution on its Axis *. A B, a Semidiameter of the Earth from the Center to any Meridian Fig. VIII.

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* The Arch A *a* is in reality greater than C *c*; for the Earth, as well as every other Planet, deſcribes in its Motion round the Sun, equal Spaces, or Areas, in equal Times. That is, if the Earth moves from A to *a*, in the ſame Time that it moves from C to *c*; the triangular Space A S *a* is equal to the Space C S *c*. But as the Triangle C S *c* is longer than A S *a*, it is manifeſt that the Arch A *a* muſt be greater than C *c*. However it is ſufficient, in the preſent Caſe, to ſuppoſe them equal.

dian at Noon Yeſterday, in Winter; D C the ſame in Summer; *a b* the ſame Semidiameter carried parallel to itſelf, after a complete Revolution, *c d* the ſame in Summer. Now the Angle A S *a* = C S F (*Eucl.* I. 15) is greater than C S *c* by the Arch F *c*, therefore *d c e* = C S *c* (*Eucl.* I. 29.) is leſs than *b a* E = (A S *a* =) C S F, therefore the Arch *d e* is leſs than *b* E, therefore *d* will come to *e* in leſs time than *b* to E.

Another Cauſe of the Difference betwixt equal and apparent Time, is the *Obliquity* of the Ecliptic to the Equator; by Means of which, Archs of the Ecliptic, bounded by Meridians that are neareſt to one another, are no where equal to Archs of the Equator, bounded by the ſame Meridians; but ſome are greater, others leſs: ſo that the Obliquity of the Ecliptic to the Equator, being greater in ſome Parts than in others, (*viz.* greater near the equinoctial Points, and leſs near the ſolſticial Points,) occaſions alſo a Difference in the Length of natural Days.

Fig. IX. For let E Q represent the Equator, E Z Q a Semicircle of the Ecliptic; the Arch E *c* upon the Ecliptic, (ſubtending the right Angle E *e c*) is greater than the correſponding Arch E *e* upon the Equator by the little Arch *a c*: but the Arch Z *n* upon the Ecliptic is leſs than the

correſponding Arch C *p* upon the Equator by the little Arch *n o*. For Z *o* is, by the Conſtruction of the Figure, taken equal to C *p*.

Suppoſe E *a* (= E *e* = Z *o* = C *p*) to be ſo much of the Ecliptic as the Sun runs over in his apparent annual Courſe, while the Earth is performing one complete Revolution on its Axis: ſuppoſe he was Yeſterday at E, when he made Noon upon the Meridian N E S, he is now, after a complete Revolution of the Earth, arrived at *a*, and muſt therefore traverſe the Line or Arch *a b* (by means of the Earth's diurnal Motion) before he will make Noon again upon the ſame Meridian.

Suppoſe again that the Sun was at Z Yeſterday, when he made Noon upon the Meridian N Z C S; he is now, after a complete Revolution of the Earth, got as far as *o*, and muſt therefore traverſe the Line or Arch *o m*, before he will make Noon again upon the ſame Meridian. Now the Line *o m* is longer than the Line *a b*, by how much the Arch of the Ecliptic *Z o* approaches nearer to a parallel Poſition to the Equator, than the Arch E *a*: therefore (ſince the Earth always performs its diurnal Motion with the ſame Degree of Swiftneſs) it will require more time for the Sun to traverſe *o m*, than *a b*. In the former Caſe, repreſented by *o m*, the natural

Day is more than 24 Hours long: then the equal Time gains upon the apparent Time, and Clocks that are well timed go faſter than Sun Dials. In the latter Caſe, repreſented by *a b*, the natural Day is leſs than 24 Hours: then the apparent Time gains upon the equal Time, and Clocks go ſlower than the Sun.

For the clearer Illuſtration of this Matter, let it be conſidered, that if the Ecliptic lay due North and South, or perpendicular to the Equator, (on which Time is meaſured) the Motion of the Sun in the Ecliptic would make no Difference at all in the Length of natural Days, but every Day would be juſt 23 Hours 56 Minutes, and the Line or Arch *b a* or *m o* would be reduced to nothing.

On the contrary, if the Ecliptic lay parallel to the Equator, every natural Day would be exactly 24 Hours; and the Line *a b* and *m o* would be equal, each repreſenting an Arch which the Sun traverſes, in his apparent diurnal Motion, in juſt 4 Minutes. But as the Ecliptic is neither perpendicular nor parallel to the Equator; but in ſome Parts it approaches nearer to a Perpendicular, (as about the equinoctial Points,) and in other Parts it approaches nearer to a parallel Poſition, (as about the ſolſticial Points,) the Arch which the Sun traverſes at the ſolſticial

Seaſons, to make Noon again after a complete diurnal Revolution, repreſented by *o m*, muſt needs be longer than the Arch which he traverſes, in the ſame Manner, about the equinoctial Seaſons, repreſented by *a b*; he will therefore be more than 4 Minutes in traverſing the Arch *o m*, and leſs than 4 Minutes in traverſing the Arch *a b*.

From theſe two Cauſes, joined together, ariſes that Difference betwixt equal and apparent Time, which is expreſſed in the Tables of Equation; which ſhow how much a Clock, if it were ſet exactly with a good Sun-Dial, when the equal and apparent Time are together, (as on the 15th of *April*, and ſuppoſing it to go at an equal Rate, meaſuring exactly 24 Hours a Day without any Variation) would go faſter or ſlower than the Sun-Dial throughout the Year.

According to the firſt of theſe two Cauſes of the Difference betwixt equal and apparent Time, (*viz.* the Excentricity of the Earth's Orbit,) Clocks ſhould go faſter than the Sun in Winter, and ſlower in Summer. According to the ſecond Cauſe, (*viz.* the Obliquity of the Ecliptic to the Equator) Clocks ſhould go faſter than the Sun at the ſolſticial Seaſons, and ſlower at the equinoctial Seaſons. Now theſe two Cauſes, which are independent on each other, ſometimes

times concur to increaſe the Difference betwixt equal and apparent Time, and ſometimes they correct or counteract one another. Hence it is, that though, according to the ſecond Cauſe, Clocks ſhould go ſlower than the Sun at both the equinoctial Seaſons, and as much ſlower at one as at the other; yet they are about 7 Minutes faſter than the Sun at the vernal Equinox, and about 7 Minutes ſlower at the Autumnal. The Reaſon is becauſe Clocks have been loſing of the Sun all the preceding Summer, according to the firſt Cauſe which therefore concurs with the ſecond Cauſe in Autumn, to make them go ſo much ſlower; whereas they have been gaining upon the Sun according to the firſt Cauſe all the foregoing Winter, which therefore counteracts and corrects the ſecond Cauſe in the Spring.

It appears by the Tables, that ſix Weeks after the vernal Equinox, Clocks are 3 Minutes ſlower than the Sun, which is 10 Minutes ſlower than they were at the Equinox; whereas ſix Weeks after the autumnal Equinox they are 16 Minutes ſlower than the Sun, which is but 9 Minutes ſlower than they were at the Equinox. The Reaſon why they have loſt more in ſix Weeks after the vernal Equinox than after the Autumnal is becauſe, according to the firſt Cauſe, Clocks begin to loſe of the Sun immediately

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FIG. VIII.

FIG. IX.

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mediately after the vernal Equinox: that Cauſe therefore concurs with the ſecond Cauſe at that Seaſon. But immediately after the autumnal Equinox they begin, according to the firſt Cauſe, to gain upon the Sun; which therefore corrects the ſecond Cauſe at that Seaſon.

The former of theſe Cauſes of the Difference betwixt equal and apparent Time (*viz.* the Excentricity of the Earth's Orbit) [illegible] fected by the Preceſſion of the Equi[illegible] for though, according to that Ca[illegible] ks do, at preſent, go faſter na[illegible] un in *Winter*, and ſlower in [illegible] yet in Proceſs of Time the [illegible] l come to [illegible] Perihelion in the [illegible] and the[illegible] ks will go ſlower [illegible] Sun i[illegible] r, and faſter in [illegible]

[illegible] re fore [illegible] the Equation of [illegible] ma[illegible] Year, are continually [illegible] ward[illegible] from Truth; but yet [illegible] Pre[illegible] e Equinoxes is ſo very [illegible] w, [illegible] e Tables may very well [illegible] rve [illegible] or more without any ſen-

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A TABLE *of the* Equation *of Days, ſhewing how much* equal Time *is faſter or ſlower than* apparent Time, *throughout the Year.*

Days	*January*		*February*		*March*		*April*		*May*		*June*	
	Faſter		Faſter		Faſter		Faſter		Slower		Slower	
	Min.	Se	M.	S.	M.	S.	M.	S	M	S.	M.	S.
1	4	6	14	13	12	48	4	1	3	8	2	47
2	4	34	14	20	12	36	3	43	3	16	2	38
3	5	2	14	27	12	23	3	25	3	23	2	29
4	5	30	14	32	12	9	3	6	3	30	2	19
5	5	57	14	37	11	55	2	48	3	36	2	9
6	6	24	14	41	11	41	2	30	3	42	1	59
7	6	50	14	44	11	26	2	13	3	47	1	48
8	7	16	14	47	11	11	1	55	3	51	1	37
9	7	41	14	48	10	56	1	38	3	55	1	26
10	8	6	14	49	10	40	1	21	3	58	1	14
11	8	30	14	49	10	24	1	4	4	0	1	2
12	8	59	14	48	10	7	0	48	4	2	0	50
13	9	22	14	47	9	50	0	32	4	4	0	38
14	9	44	14	44	9	33	0	16	4	5	0	26
15	10	5	14	41	9	16	0	* 1	4	5	0	13
16	10	26	14	37	8	58	0	*14	4	5	0	* 1
17	10	46	14	33	8	40	0	29	4	4	0	*12
18	11	5	14	28	8	22	0	43	4	2	0	25
19	11	24	14	22	8	4	0	57	4	0	0	38
20	11	42	14	15	7	46	1	11	3	58	0	50
21	11	59	14	8	7	27	1	24	3	55	1	3
22	12	15	14	0	7	9	1	37	3	51	1	16
23	12	30	13	52	6	50	1	49	3	47	1	29
24	12	45	13	43	6	31	2	1	3	42	1	42
25	12	59	13	33	6	13	2	12	3	37	1	55
26	13	12	13	22	5	54	2	23	3	31	2	7
27	13	24	13	12	5	35	2	33	3	25	2	20
28	13	36	13	0	5	16	2	43	3	18	2	32
29	13	46			4	57	2	52	3	11	2	44
30	13	56			4	39	3	0	3	3	2	56
31	14	5			4	20			2	55		

Equal Time faſter as far as the two Stars.

*Equal time ſlower

Equal Time faſter

A TABLE *of the* Equation *of Days.*

Days	*July*		*Auguſt*		*September*		*October*		*November*		*December*	
	Faſter		Faſter		Slower		Slower		Slower		Slower	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S
1	3	8	5	46	0*	18	10	23	16	13	10	32
2	3	19	5	42	0	36	10	42	16	13	10	9
3	3	31	5	38	0 Equal	55	11	0	16	13	9	45
4	3	42	5	33	1	14	11	18	16	12	9	20
5	3	52	5	28	1	34	11	36	16	10	8	55
6	4	2	5	22	1	54	11	53	16	8	8	29
7	4	12	5	15	2	14	12	10	16	4	8	3
8	4	22	5	8	2 Time ſlower	34	12	27	16	0	7	37
9	4	31	5	0	2	54	12	43	15	54	7	10
10	4	40	4	52	3	14	12	58	15	48	6	42
11	4	48	4	43	3	35	13	13	15	41	6	14
12	4	56	4	34	3	55	13	28	15	34	5	46
13	5	4	4	24	4	16	13	42	15	25	5	18
14	5	11	4	13	4	37	13	56	15	16	4	49
15	5	17	4	2	4	58	14	9	15	6	4	19
16	5	23	3	50	5	19	14	22	14	55	3	50
17	5	29	3	38	5	40	14	33	14	43	3	20
18	5	34	3	26	6	1	14	45	14	30	2	51
19	5	39	3	12	6	22	14	56	14	16	2	21
20	5	43	2	59	6	42	15	6	14	2	1	51
21	5	46	2	45	7	3	15	15	13	46	1	20
22	5	49	2	30	7	24	15	24	13	30	0	*50
23	5	51	2	15	7	44	15	32	13	13	0	20
24	5	53	2	0	8	5	15	40	12	56	0 Equal	10
25	5	54	1	44	8	25	15	46	12	38	0	40
26	5	55	1	28	8	45	15	52	12	18	1	10
27	5	55	1	11	9	5	15	58	11	58	1	40
28	5	54	0	54	9	25	16	2	11	38	2 Time faſter	10
29	5	53	0	36	9	45	16	6	11	17	2	39
30	5	51	0	19	10	4	16	9	10	55	3	8
31	5	49	0	*1			16	11			3	37

CHAP. X.

Of PARALLAXES.

THE Difference betwixt the *true Place* of the Sun, or Planet, and its *viſible* or *apparent Place*, is called its *Parallax*. By the true Place is meant the Place where it would appear, among the fixed Stars, if it were ſeen from the Center of the Earth. The apparent Place is where it *does* appear, when ſeen from the Earth's Surface. This Difference is greateſt when the Planet is at the Horizon, and gradually decreaſes as it riſes higher, till, when it comes to the Zenith, it has no Parallax at all.

Fig. X. Let C be the Center of the Earth; O the Place of Obſervation on its Surface. Let Q P N repreſent a Quadrant of the Planet's apparent diurnal Path, and L V Z the Starry Firmament. Now when the Planet is at P, were it to be ſeen from the Earth's Center, it would appear in the Firmament at T; but to an Obſerver, viewing it from the Surface at O, it appears in the Horizon at H. The

Arch H T, or the Angle H P T, or O P C, is called its *Horizontal Parallax*. When the Planet riſes to S, the Arch V R, which is leſs than H T, meaſures its Parallax; at N it has no Parallax at all. Theſe are called *Diurnal Parallaxes*.

Fig. XI. The Angle which is formed by a Right Line, drawn from the Earth to the Sun, and another from the Sun to the Moon, at either of her Quadratures, is called the *Menſtrual Parallax* of the Sun.

Dr. *Hook* and Mr. *Flamſteed* thought they had diſcovered an *annual Parallax* of the fixed Stars, of about 45″; Fig. XII. that is, an Angle produced by two right Lines, drawn from the ſame fixed Star, to two oppoſite Points in the Earth's annual Orbit. But Mr. *Bradley* has ſince accounted for that ſuppoſed Parallax another Way. He conceives it to proceed from the progreſſive Motion of the Star's Light *.

The Sun or a Planet's Diſtance from the Earth, and conſequently its real Magnitude, is found by its Parallax. For in every Triangle, if *two Sides* and *one Angle*, or *one Side* and *two Angles*, be known, all the other Sides and Angles are certainly found by Trigonometry. Thus in the Triangle O P C (Fig. X.) the Side O C

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* *Philoſ. Tranſact.* N° 406.

(which is the Earth's Semidiameter) being known, and the Angle at O, which is a right Angle; if the Angle at P can alſo be found, the Side P C, which is the Planet's Diſtance from the Earth, is alſo diſcovered *. And the Diſtance being once known, the true Magnitude may be computed from its apparent Diameter. For, having the apparent Diameter, we can find, by the Help of trigonometrical Tables, what Proportion its real Diameter bears to its Diſtance. For let D E be the apparent Diameter, ſeen by an Eye at F; then as the Radius of a Circle is to the Tangent of the Angle D F E, ſo is the Diſtance F E to the real Diameter of the Object. And from the Diameter, the Magnitude of a Globe is eaſily computed. Fig. XIII.

Aſtronomers have contrived various Methods for finding the Parallax of the heavenly Bodies; for a Specimen of which take the following, from Dr. *Keill*'s Aſtronomical Lectures, Lect. XXI.

In an Eclipſe of the Moon obſerve when both its Horns are in the ſame vertical Circle, and then in that Moment take the Altitudes of both Horns: The Difference of theſe two Altitudes being halfed and added to the leaſt, or ſubſtracted from the greateſt, does give nearly the viſible Altitude of the Moon's Center: But the true Altitude is nearly equal to the Altitude of the Center of the Shadow at that Time. Now we know the Altitude of the Center of the Shadow, becauſe we know the Place of the Sun in the Ecliptic, and its Depreſſion under the Horizon, which is equal to the Altitude of the oppoſite Point of the Ecliptic, in which is the Center of the Shadow. And therefore we have the true Altitude of the Moon and the apparent Altitude, whoſe Difference is the Parallax, which will therefore be known.

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* Becauſe as the ſine of P is to O C, ſo is the radius to P C.

CHAP. XI.

Of the Fixed Stars.

THAT the Fixed Stars are at a very great Diſtance from the Earth, may be concluded from the North Pole of the Earth pointing as directly to the Pole Star *, when the Earth is at Aries, as when it is at Libra; though thoſe two Points in the Earth's Orbit are at the Diſtance of 162,000,000 Miles from each other, which, it ſeems, amounts to no more than an inſenſible Point, in reſpect to the Diſtance of the fixed Stars.

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* The Pole Star is a Star of the ſecond Magnitude, in the Tip of the Tail of the *little Bear*, and is very near the exact North Pole of the World.

The fixed Stars being viſible to us at ſuch a vaſt Diſtance, makes it highly probable that they are very large Bodies.

They are probably alſo at vaſt Diſtances from one another, which may be one Cauſe of their appearing of ſuch different Magnitudes. They ſeem, by the Luſtre of their Appearance, to emit Light like the Sun; and, indeed, if they only reflected Light, they could hardly be viſible to us at all at ſo great a Diſtance.

Scarce 2000 Stars can be ſeen by the naked Eye; but ten, or, perhaps, twenty times more, may be diſcerned by Teleſcopes.

Thus, in the *Pleiades*, where only ſix Stars are to be ſeen with the naked Eye, Dr. *Hook* counted 78 with a Twelve-foot Teleſcope; and with longer Teleſcopes he diſcovered a great many more. (See his *Micography*, p. 241.) And in the Conſtellation *Orion*, where but 62 Stars can be counted with the naked Eye, 2000 have been numbered with the help of Teleſcopes.

Can we think that God made theſe vaſt and numerous Bodies only to twinkle to us in the Night? Or is it not a more reaſonable Conjecture that the fixed Stars are all Suns with planetary Worlds moving round them, like our Sun? which, perhaps, is no other than one of the fixed Stars.

All the fixed Stars are like the Sun, immoveable in their Places, but all of them are not invariable as to the Luſtre of their Appearance. Some of them appear and diſappear periodically, as that in the Neck of the *Whale*, which is inviſible for eight or nine Months in the Year; and in the other three or four Months of its Appearance, it is continually changing its Luſture and Brightneſs; which may, perhaps, be owing to the Star's being covered with dark Spots, ſuch as we ſee in the Sun, over the greateſt Part of its Surface. And, ſuppoſing it to have a Rotation on its Axis, like our Sun, but ſlower; it preſents, at ſome Times, its bright Part to our View, upon which it becomes viſible; at other Times it turns its dark Side to us, and then we cannot ſee it.

New Sars have alſo been obſerved to appear, as one in the *Swan's Breaſt*, which was firſt taken Notice of by *Kepler*, in the Year 1600. And old Stars have diſappeared, and become inviſible. For Inſtance, one in the *Pleiades*, which were formerly ſeven Stars, and are called ſo ſtill, though no more than ſix have been viſible to the naked Eye for ſeveral Ages paſt. It

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ſeems the ſeventh was loſt as long ago as *Ovid*'s Time, by this Verſe in the third Book of his *Faſti:*

> *Quæ ſeptem dici, ſex tamen eſſe ſolent.*

And we are aſſured by the Catalogues of the fixed Stars, which were made by the ancient Aſtronomers, and even ſo late as by *Tycho*, that ſeveral Stars were obſerved by them, which are now become inviſible. But whether theſe are periodical Stars, like that in the *Whale's Neck*, only with a ſlower Motion; or whether the new ones are new Creations; and whether the old ones, that have diſappeared, are burnt out and extinguiſhed; are Matters which ſurpaſs the Knowledge of the Philoſophers of this World.

COROLLARY.

From this View of the fixed Stars, a probable Argument may be deduced for the Earth's diurnal Motion, *viz.* that ſuch a Motion of the Earth is more probable, (as being more agreeable to the Wiſdom of the divine Architect) than the diurnal Rotation of all the fixed Stars, as well as of the Sun and Planets round the Earth. To illuſtrate this Argument, ſuppoſe but a hundred Men ſitting round a great Room, attending on a Lecture of Geography, and a coma common Terreſtrial Globe placed in the midſt of them. Now which would be the beſt Way to ſhew all the Parts of the Globe to each Perſon ſucceſſively? Whether by turning the Globe round its Axis; or, by a vaſt deal of Machinery and Wheel-work, to make the Room, and all the Seats in it, turn round the Globe? Which Way any wiſe and ſkilful Man would take, in this Caſe, is eaſy to determine.

It is a further Probability on the Side of the Earth's diurnal Rotation, that *Venus*, *Mars*, and *Jupiter*, are certainly known to revolve on their Axes; and it is highly probable the Earth does ſo too. As for *Saturn* and *Mercury*, the one is ſo remote from us, the other ſo near the Sun, that we have not been able to diſcover any Spots on the Surface of either of them, by which to judge whether they revolve on their Axes or no. Another and more certain Proof of the diurnal Rotation of the Earth is deduced from the Shape of it, which is an *oblate Sphæroide*, having its Diameter at the Equator above 30 Miles longer than from Pole to Pole. This, no doubt, ariſes from a diurnal Rotation; as it is certain that ſuch a Rotation of the Earth muſt neceſſarily give it the ſame ſphæroidical Form which it is found in Fact to bear.

As

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As for thoſe Scripture Expreſſions. The *Sun's riſing* and *going down*, *running his Race*, *ſtanding ſtill*, &c. they are true and proper Deſcriptions of the Phænomena, as they appear to us; but by what Motions thoſe Phænomena are occaſioned, theſe Expreſſions not do at all determine.

That ſome Part, at leaſt, of the Account of the Sun and Moon's ſtanding ſtill in the 10* Chapter of *Joſhua*, is merely a Deſcription of the Appearance, is evident, in that the *Sun* is ſaid to *ſtand upon Gibeon*, and the *Moon in the Valley of Ajalon*. Now *Gibeon* and *Ajalon*, and indeed the whole Land of *Canaan*, lies in too Northern a Latitude for either Sun or Moon ever to be vertical too, or directly over, any Part of it. However, this was a juſt Deſcription of the Phænomenon as it appeared to *Joſhua*, in the Place where he then was, where the Sun ſeemed to be upon *Gibeon*, and the Moon over the Valley of *Ajalon*; (juſt as the Sun often appears to us to be directly over this or that Tree or Steeple, though we know the Place to which he is then really vertical is ſome Thouſands of Miles off.) But if *Joſhua* had been then in another Part of the Country, the Sun and Moon would have appeared to him, not as over *Gibeon* and *Ajalon*, but over other Places; while yet, in Reality, neither of them were over any Place that he could then ſee. Now if one Part of the Account, *viz.* that which reſpects the Place of the Sun, be nothing elſe but a Deſcription of the Phænomenon, as it appeared, and not as it was in Reality; I ſee no Reaſon why the other Part, reſpecting the Sun's moving or ſtanding ſtill, ſhould be underſtood any otherwiſe. And I ſhould think it might as well be proved, from this Text, that the Sun did then depart from the Ecliptic, and came at leaſt 7 Degrees Northward, to ſtand over *Gibeon*; as that, it is the Motion of the Sun, and not of the Earth, which occaſions the Succeſſion of Days and Nights.

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PART

PART III.

CHRONOLOGY.

CHAPTER I.

Of the Diviſions of TIME.

THE moſt common Diviſions of Time are into *Days*, *Hours*, *Weeks*, *Months* and *Years*.

I. DAYS are either *Natural* or *Artificial*.

A *Natural Day* is the Space of Time which flows while the Sun goes from any Meridian to the ſame Meridian again; or from any Hour one Day, to the ſame Hour the next Day. Theſe Days are always of the ſame Length, very nearly.

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An *Artificial Day* is from Sun-riſe to Sun-ſet. Theſe Days are of different Lengths, at different Times of the Year, all the World over, except at the *Equator* and the *Poles*.

Different Nations have begun the natural Day differently.

The *Jews* began the Day from Sun-ſet.

The *Babylonians* from Sun-riſing.

The *Egyptians* from Midnight; in which they are followed by moſt modern Nations of *Europe*.

Only the *Aſtronomers* begin the Day at Noon, and count 24 Hours till the Noon of the next Day, and not twice twelve, according to vulgar Computation.

II. HOURS are alſo either *Natural* or *Artificial*.

A *Natural Hour* is the 24th Part of a *natural Day*. The Hour is divided into 60 *Minutes*; the Minute into 60 *Seconds*, &c.

An *Artificial Hour* is the 12th Part of the *artificial Day*, or *Night*. This was uſed by ſome of the Ancients.

III. A WEEK is a Syſtem of ſeven Days. The Firſt is called *Sunday*, or *Lord's-Day*. The Second, *Monday*, &c. In Latin they are named after the Planets. Sunday is *Dies Solis*; Monday, *Lunæ*; Tueſday, *Martis*;

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Martis; Wedneſday, *Mercurii*; Thurſday, *Jovis*; Friday, *Veneris*; Saturday, *Saturni* *.

IV.

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* The ancient *Saxons* had a great many Idols, ſeven of which were appropriated to the ſeven Days of the Week, becauſe of ſome Worſhip that was paid to each Idol on its reſpective Day, *viz.*

1. The Sun.

2. The Moon.

3. Tuisco, who had been a Man of great Renown among the *Germans*, after whom they called themſelves *Tuitſhen*, that is, *Tuitſhmen*; from whence comes the modern Name *Dutchmen*. The *third* Day of the Week was eſpecially dedicated to the Worſhip of this Idol, which was therefore called *Tuiſday*, or *Tueſday*.

4. Woden, who had been a famous Warrior, and was therefore honoured as the God of Battle, in like Manner as *Mars* was among the *Romans*. He was chiefly worſhipped on the *fourth* Day of the Week, which was called *Wodenſday* or *Wedneſday*.

5. Thor, the God who was ſuppoſed to govern the Winds and Clouds, and to whom they prayed for ſeaſonable Weather, and that eſpecially on the *fifth* Day of the Week, called therefore *Thorſday* or *Thurſday*.

6. Friga, a Goddeſs, reputed the giver of Peace and Plenty; for which Gifts they prayed to her chiefly on the *ſixth* Day, which was therefore called *Frigedead*; from whence comes the Name *Friday*.

Seater, to whom they prayed for Protection, Freedom and Concord; and alſo for the Fruits of the Earth. He was worſhipped on the *ſeventh* Day of the Week, which therefore received the Name *Seater-day* from this Idol; or, as we now write it, *Saturday*.

The *Romans* finding, or fancying, ſome Reſemblance between the Attributes of thoſe *Saxon* Idols, and ſeveral of their Gods, imagined them to be the ſame. As *Woden* they ſuppoſed to be *Mars*, *Thor* to be *Jupiter* the Thunderer; *Friga* to be *Venus* the Goddeſs of Love and Friendſhip; and eſpecially becauſe *Venus* was honoured by them on the ſame Day of the Week. *Seater* they miſtook

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IV. MONTH'S are either *Aſtronomical* or *Civil.*

The *Aſtronomical Month* is either *Lunar* or *Solar.*

The *Lunar Month* is that Space of Time which the Moon takes up in performing its Courſe through the Zodiac.

The *Solar Month* is that Space in which the Sun goes through one Sign, or 30 Degrees of the Zodiac.

The *Civil* or *Kalendar Month* conſiſts of a certain Number of Days, according to the Laws or Cuſtoms of different Countries. The Engliſh, and moſt other European Nations, make 12 Months in a Year, *viz. January, February, March, April, May, June, July, Auguſt, September, October, November, December.*

The Number of Days in each Month is found by the following Canon.

Thirty Days hath *September,*
April, June, and *November,*
February hath Twenty-eight alone,
All the reſt have Thirty-one.

---

for *Saturn,* merely becauſe of the like ſounding of the Name.
Vid. *Verſtegan's Reſtitution of decayed Intelligence,* Page 68.

V. YEARS

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V. YEARS are again either *Aſtronomical* or *Civil.*

The *Aſtronomical Year* is either *Solar* or *Lunar.*

The *Solar Year* is *Siderial*, or *Tropical.*

The *Siderial Year* is the Space that flows while the Sun is paſſing from any fixed Star, to the ſame again. It conſiſts of 365 Days, 6 Hours, 9 Minutes, 14 Seconds.

The *Tropical Year* is the Space that flows while the Sun paſſes from either Tropic, or from any Point of the Ecliptic, to the ſame again. This is ſomewhat ſhort of the Siderial Year, becauſe every Point of the Ecliptic goes backwards about 50 Seconds of a Degree in a Year, (as was ſhewed Part II. Chap. 3.) thereby meeting the Sun, as it were; which makes the Sun return to the ſame Point of the Ecliptic, about 20 Minutes of Time before he arrives at the ſame fixed Star, where that Point of the Ecliptic was when the Sun was in it a Year ago. The *Tropical Year* therefore is ſhorter than the *Siderial Year*, and conſiſts of 365 Days, 5 Hours, 48 Minutes, 57 Seconds.

The *Lunar Year* is either *Wandering* or *Fixed.*

The *Wandering lunar* Year conſiſts of 12 lunar ſynodical Months; which wants 11 Days of the ſolar Year. This Year is uſed by the *Turks* and other *Mahometans*; ſo that the Beginning of their Year is perpetually ſhifting through the ſeveral Seaſons, and it revolves in 32 Years.

The *Fixed Lunar* or *Lunæ-ſolar Year* conſiſts ſometimes of 12 ſynodical Months, ſometimes of 13; as will be ſhewn afterwards.

The *Civil Year* is either *Julian* or *Gregorian.*

The *Julian* is ſo called from *Julius Cæſar*, by whom it was fixed 40 Years before Chriſt. It conſiſts of 365 Days; only every fourth Year, which is called *Biſſextile*, or *Leap Year*, conſiſts of 366. The additional Day is now put to the End of *February*, ſo that *February* has that Year 29 Days: But in the ancient *Roman* Calendar the ſixth of the Calends of *March*, anſwering to our 24th of *February*, was that Year reckoned twice over; from whence is the Name *Biſſextile.*

The *Gregorian Year* is ſo called from Pope *Gregory* XIII. by whoſe Order the Calendar was reformed A. D. 1582. It begins at preſent 11 Days before the *Julian.* Every centeſſimal or hundredth Year from the Birth of Chriſt, as 1500, 1600, 1700, &c. is Leap Year, according to the *Julian* Account; but according to the *Gregorian*, it is always a common Year, except when the Number of Centuries can be divided by 4 without a Remainder, for then it is Leap Year. Thus the Years 1600 and 2000 are Leap Years; but the intermediate centeſſimal Years are common ones. So that the Gregorian Year, or *New Style*, which is now generally uſed, gets before the Julian, or *Old Style*, 3 Days in 400 Years.

* *To know if it be* Leap Year.

Leap Year is given, when four will divide
The Cent'ries compleat, or odd Years beſide.

EXAMPLE *for* 1766.

66 ÷ 4 = 2, not Leap Year.

4)66(2 not Leap Year.
16

EXAMPLE *for* 2000.

20 ÷ 4 rem. 0, Leap Year.

4)20(0 Leap Year.
5

CHAP.

CHAP. II.

Of CALENDARS.

THE Calendar (in Arabic *All-Manach*, from whence is the Engliſh word *Almanack*) is a Table, in which all the Days of the Year are ſet down ſucceſſively; with *Holy-Days*, both *eccleſiaſtical* and *civil*, *Terms*, *&c.* marked in their proper Places. This Table of Days is divided into 52 Weeks, of 7 Days each, and 1 Day over, by Means of the firſt Seven Letters of the Alphabet A, B, C, D, E, F, G, perpetually recurring throughout the Year. A ſtands againſt the 1ſt of *January*. B againſt the 2d, and ſo on to *December* the 31ſt, which has A joined to it. The Letter which ſtands againſt all the *Sundays* of the Year, is called the *Dominical* or *Sunday Letter*, for that Year. If *January* the 1ſt be *Sunday*, A is the *Dominical Letter*, which ſtands againſt every *Sunday* throughout the Year, except it be Leap Year; for then the Dominical Letter changes at the End of *February*, moving a Letter backwards: ſo that G will be the *Sunday* Letter during the Remainder of the Year; for the Dominical Letter always ſhifts backwards, as from A to G, from G to F, and from F to E. If E be the Dominical Letter this Year, D will be the next.

* *To find the* Dominical Letter *for any Year.*

Divide the Cent'ries by 4; and twice what does remain
Take from 6; and then add to the Number you gain
The odd Years and their 4th; which dividing by Seven,
What is left take from 7, and the Letter is given.

EXAMPLE *for* 1766.

$17 \div 4$ remains 1
$1 \times 2 = 2$
$4 + 66 + 16 = 86$
$86 \div 7$ remains 2
$7 - 2 = 5 =$ E, the Dominical Letter.

```
4)17(1
   4 2
     2
     6
    ——
     4
    66
    16 7
  ————————
  7)86(2
     12 5=E.
```

* Every common Year brings the Dominical Letter *one* backward, and every Leap Year *two*; therefore to any Number of Years, under 100, add its 4th Part for the Leap Years, omitting Fractions; and the Sum will be the Number of Times the Letter has ſhifted backward during that Number of Years, which being divided by 7, the Remainder will be the Number of the Letter of the preſent Year, reckoning from the Letter belonging to the laſt centeſſimal Year in a retrograde Order; or the Complement of the Remainder to 7 will be the preſent Dominical Letter in a direct Order, as will appear by the following Example.

By the Dominical Letter, *you may compute on what Day of the Week any Day of the Month will fall throughout the Year, by the following* Canon.

At

Let the Letter of the laſt centeſſimal Year be G, and ſuppoſe the given Year to be 77.

$77 \div 4 = 19$
$77 + 19 = 96$
$96 \div 7$, remains 5
$7 - 5 = 2$

5 backward from G=B.
2 forward from G=B.

When the centeſſimal Year, which is the laſt of the Century, is *common*, that Century will bring the Dominical Letter two forward; (100 Years + 24 Leap Years = 124; 124 ÷ 7 Remains 5; 7—5=2). But when the laſt Year is *Leap Year*, that Century will bring the Dominical Letter but one forward (100 Years + 25 Leap Years = 125; 125 ÷ 7, Remains 6; 7—6=1). Conſequently, 4 Gregorian Centuries will compleat a Revolution of the Letter: Thus the Dominical Letter is for the Year 1600 A; 1700 C; 1800 E; 1900 G; 2000 A; &c. Now as A, the ſixth Letter backward from G, is the Dominical Letter of a *Biſſextile* centeſſimal Year, (which is when the Number of Centuries is diviſible by 4 without any Remainder) the Rule to find it until the next hundredth Year will be, To divide the odd Years, their 4th Part, and 6, by 7; and the Remainder ſubſtracted from 7, will give the Number of the Letter, reckoning A 1, B 2, &c. But as the firſt common Century brings it two Letters forward from A, or two leſs backward from G, the Remainder, after dividing the Centuries by 4, muſt be doubled; then 6—2=4, therefore 4 muſt be added to the odd Years and their 4th in order to find the Dominical Letter till the laſt Year of the ſecond *common* Century; and, for the ſame Reaſon, 2 muſt be added in the next Century, and 0 in the fourth. Whence it eaſily appears, that the Rule for finding the Dominical Letter may be abridged during the preſent Century to this:

Divide the odd Years, their fourth and four by ſeven,
What is left ſubſtract from ſeven the Letter is given.

1 2 3 4 5 6
At Dover Dwells George Brown Eſquire,
7 8 9 10 11 12
Good Chriſtopher Finch, And David Frier.

Where the 12 Words anſwer to the 12 Months; the firſt Letter of each Word ſtands in the Calendar againſt the firſt Day of the correſponding Month, as A againſt *January* the 1ſt, D againſt *February* the 1ſt, *&c.* Suppoſe B is the Dominical Letter, I would know on what Day of the Week *June* the 24th falls that Year. E ſtands againſt *June* the 1ſt, *per* Canon. Remember that the 1ſt, 8th, 15th, 22d, 29th, is the ſame Day of the Week in each Month. Now if B be *Sunday*, E is *Wedneſday*; therefore *June* the 22d is *Wedneſday*, and the 24th is *Friday*.

CHAP. III.

Of CYCLES.

CYCLES, or Periods, are ſuch Spaces of Time as revolve into themſelves again; of which Sort the moſt conſiderable are,

The Cycle { of the Sun,
of the Moon,
of the Roman Indiction.

1. The

EXAMPLE for 1766.

$\underline{66+16+4}\div 7=86\div 7=12\tfrac{2}{7}$, or 2 remains.

$7-2=5=$ E, the Dominical Letter; and ſubſtituting 2 for 4 in the firſt Line, the Rule will hold for the next Century,

1. The Cycle of the Sun conſiſts of 28 Years, which contain all the poſſible Combinations of the Dominical Letters, in reſpect to their ſucceſſive Order; as pointing out common Years and Leap Years: ſo that after the Expiration of the Cycle, the Days of the Month return in the ſame Order to the ſame Days of the Week, throughout the next Cycle. Except that upon every centeſſimal Year, which is not a Leap Year, the Letters muſt all be removed one Place forward, to make them anſwer to the Years of the Cycle. For Inſtance, If the Year 1800 were a *Leap Year*, as every centeſſimal Year is in the Julian Account, the Dominical Letters would be E D, and C would be the Dominical Letter of the next Year; but as it is a *common Year* in the Gregorian Account, D is the Dominical Letter of 1801, which anſwers to the 18th of the Cycle; C to the 19th &c. until the next centeſſimal Year.

The Dominical Letter of each Year in this Cycle, until the Year 1800, appears in the following Table.

1	DC	6	D	11	E	16	F	21	GF	26	G
2	B	7	C	12	D	17	ED	22	E	27	F
3	A	8	B	13	CB	18	C	23	D	28	E
4	G	9	AG	14	A	19	B	24	C		
5	FE	10	F	15	G	20	A	25	BA		

2. The Cycle of the Moon is a Period of 19 Years, after which the new and full Moons return on the ſame Days of the Months; only 1 Hour 28 Minutes ſooner; So that on whatever Days the new and full Moons fall this Year, they will happen 19 Years hence on the ſame Days of the Months. Except when a centeſſimal *common* Year falls within the Cycle, that will remove the new and full Moons a Day later in the Calendar, than otherwiſe they would have fallen; ſo that a new Moon which fell, before the centeſſimal Year, ſuppoſe on March 10th, will fall 19 Years afterwards on March 11th.

The Number of the Years in this Cycle is called the *Prime*, from its uſe in pointing out the firſt Day of the Moon (*Primum Lunæ*) and the *Golden Number*, as deſerving to be writ in Letters of Gold.

The *Golden Numbers* are thoſe placed in the firſt Column of the Calendar, betwixt *March* 21 and *April* 18th, both incluſive, to denote the Days upon which thoſe full Moons fall, which happen upon or next after *March* 21ſt in thoſe Years, of which they are reſpectively the *Golden Numbers*. The day of ſuch full Moon, or the Number of Days from *March* 1ſt to that Day incluſive, is called the *Paſchal Limit*, the next Sunday after which is *Eaſter Day*. From whence it appears that Eaſter can never fall facing p. 126.

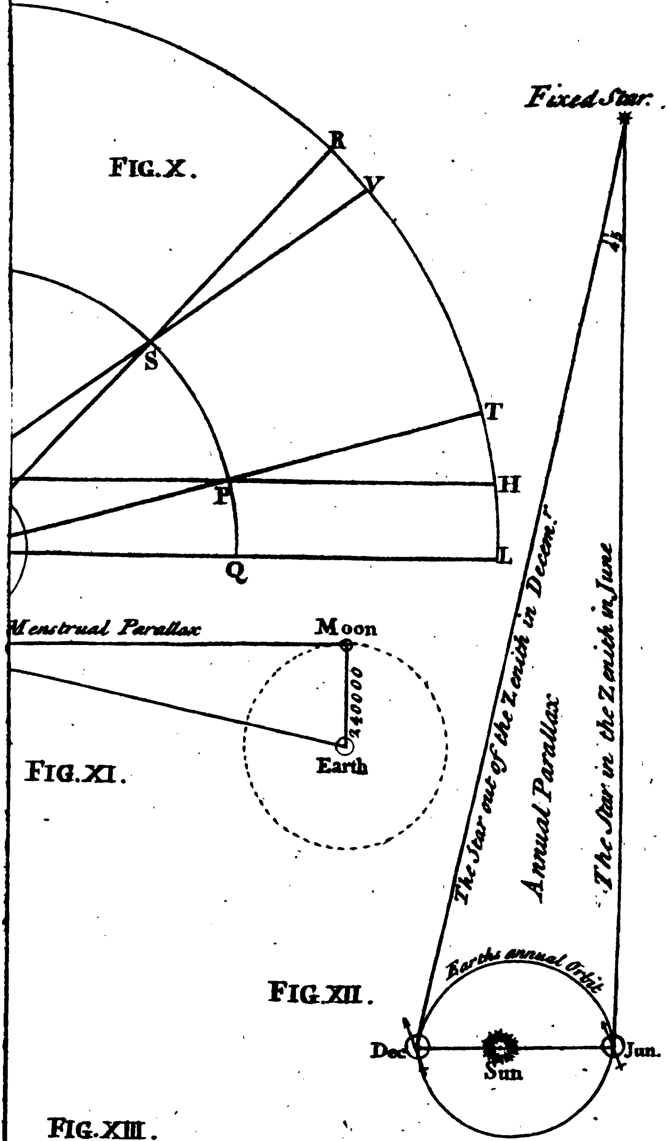
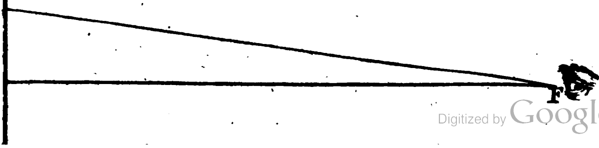


FIG. XIII.



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ſooner than *March* 22d, nor later than *April* 25th; becauſe thoſe two Days are the earlieſt and lateſt *Sundays* that can poſſibly fall *next after the firſt full Moon on or after the* 21ſt *of March*. Theſe Numbers ſo placed will mark the Day of the *Paſchal Limit*, 'till the Year 1900, when they will need ſome Alteration, as may be ſeen in *The Earl of Macclesfield's Remarks upon the Solar and the Lunar Years, in Philoſ. Tranſact.* N° 495.

3. The Cycle of the *Roman Indiction* is a Period of 15 Years, which was uſed by the ancient *Romans*, but for what Purpoſe is not now known. It is however uſed by the Popes, who date their Acts by the Years of the *Indiction*.

The Golden Number, Cycle of the Sun, *and* Indiction *are found for any Year by this* Canon.

When 1, 9, 3, to the Year have added been,
Divide by *Nineteen*, *Twenty-eight*, *Fifteen:*
By what remains each Cycle's Year is ſeen †.

Ex-

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† The Reaſon of adding theſe Numbers, *viz.* 1 for the *Golden Number*, 9 for the *Cycle of the Sun*, and 3 for the *Indiction*, to the Date of the Chriſtian Æra, is becauſe ſo many Years of the reſpective Cycles were elapſed when the Chriſtian Æra began. If then you divide the current Year of Chriſt, with the Addition of the reſpective Number, by the whole Number of the Cycle, the

Example *for* 1766.

1766	1766	1766
1	9	3
19)1767(43	28)1775(63	15)1769(117
57	95	26
0=19=G. N°.	11=Cy. S.	119
		14=R. Indic.

Theſe three Cycles, multiplied into one another; that is, 28×19×15, amount to 7980, which is called the *Julian Period*, after which the three foregoing Cycles will begin again together. This Period had its imaginary Beginning 710 Years before the Creation, and is not yet complete. It is much uſed in Chronological Tables.

the Quotient ſhews how many compleat Cycles have run out, ſince the beginning of that in which the Chriſtian Æra commenced, and the Remainder, if any; ſhews the preſent year of the Cycle; if there be no Remainder it is the laſt Year, which compleats the Cycle.

CHAP.

CHAP. IV.

Of the EPACT.

THE Epact is a Number ariſing from the Exceſs of the Solar Year above the Lunar, of 12 ſynodical Months, which Exceſs is 11 Days; or the Epact of any Year expreſſes the Number of Days from the laſt new Moon of the old Year, (which was the beginning of the preſent Lunar Year) to the 1ſt of *January*. The firſt Year of the Cycle of the Moon the Epact is 0, becauſe the Lunar Year begins with the Solar. On the ſecond, the Lunar Year has begun 11 Days before the Solar Year, therefore the Epact is 11. On the third it has begun twice 11 Days before the Solar Year, therefore the Epact is 22. On the fourth it begins three times 11 Days ſooner than the Solar Year; the Epact would therefore be 33, but 30, being an intire Synodical Month, muſt that Year be intercalated; or that Year muſt be reckoned to conſiſt of 13 Synodical Months, and there remains 3, which is the true Epact of the Year; and ſo on to the End of the Cycle, adding 11 to the Epact of the laſt Year, and always rejecting 30, gives the Epact of the preſent Year. Thus to adjuſt the Lunar Year to the Solar, through the whole Cycle of 19 Years, 12 of them muſt conſiſt of 12 Synodical Months each, and 7 of 13, by adding a Month of 30 Days to every Year when the Epact would exceed 30, and a Month of 29 Days to the laſt Year of the Cycle, which make in all 209 Days, *i. e.* 19 × 11; ſo that the *Intercalary* or *Embolimean* Years in this Cycle are 4, 7, 10, 12, 15, 18, 19.

* *A general Rule to find the* Gregorian Epact.

Let the Cent'ries by 4 be divided, and then
What remains multiplied by the Number 17;
Forty-three times the Quotient, and 86
more
Add to that; and dividing by 5 and a
Score;

From

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* If the new Moons returned exactly at the ſame Time after the Expiration of 19 Years, as the Council of Nice ſuppoſed they would do (when they fixed the Rule for the Obſervation of Eaſter, and marked the Days of the new Moons in the Calendar for each Year of the Lunar Cycle) then the Prime multiplied by 11 would always give the Epact: But in a Julian Century the new Moons anticipate, or happen earlier than that Council imagined they would, by $\frac{8}{25}$ of a Day. In a Gregorian *Common Century*, which is one Day ſhorter than a Julian Century, they happen $\frac{17}{25}$ of a Day later (1 Day $-\frac{8}{25}=\frac{17}{25}$) Now $\frac{17}{25}\times3=\frac{51}{25}$ for the three *common* Centuries; but $\frac{8}{25}$ being ſubſtracted on account of the Grego-

rian

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From 11 times the Prime, ſubſtract the
last Quote,
And rejecting the Thirties, gives the Epact you ſought †.

EXAMPLE *for* 1766.

$17 \div 4 = 4$ remains 1
$1 \times 17 = 17$
$43 \times 4 + 86 + 17 = 275$
$275 \div 25 = 11$
11×19 (G. No.) $= 209$
$209 - 11 = 198$
$198 \div 30 = 18 =$ Epact.

4)17(1
4 17
43
172
86
17
25)275(11
25

G. N°. $= 19$
11
209
11
30)198(6
18 = Epact.

* *To find the Epact until the Year* 1900.

The Prime wanting one multiplied by 11,
And the Thirties rejected, the Epact is
given †.

EXAMPLE

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rian *Biſſextile Century*, there will remain $\frac{43}{25}$. Therefore in 4 Gregorian Centuries the new Moons will happen later by $\frac{43}{25}$ of a Day, and the Epacts muſt be decreaſed accordingly. At preſent the Gregorian Epact is 11 Days ſhort of the Julian Epact; but the Quotient of the Number of the Centuries divided by 4, which at this time is 4, multiplied (as the Rule directs) by $\frac{43}{25}$, with the Addition of the Remainder 1 multiplied by $\frac{17}{25}$, makes in all but $\frac{189}{25}$ or 7 Days + $\frac{14}{25}$, therefore $\frac{86}{25}$ *i. e.* 3 Days + $\frac{11}{25}$ muſt be added to compleat the 11 Days; and the Rule thus adjuſted to the preſent Time will hold true ever afterward.

*† The Reaſon of this Rule is, that the laſt Quotient which is to be ſubſtracted from 11 times the Prime, according to the foregoing general Rule, will always be 11 — until the Year 1900. Now Prime — 1 × 11 = Prime × 11 — 11.

EXAMPLE.

G.N°.=19
1
18
11
30)198(6
18=Epact.

$\overline{\text{G.N}^{\circ}.\ 19-1}\times 11=198$
$198\div 30=18=$Epact.

A Table of the Golden Numbers and their correſponding Epacts until the Year 1900.

G.N.		Epac.	G. N.		Ep.	G. N.		Ep.	G. N.		Ep.
1	—	0	6	—	25	11	—	20	16	—	15
2	—	11	7	—	6	12	—	1	17	—	26
3	—	22	8	—	17	13	—	12	18	—	7
4	—	3	9	—	28	14	—	23	19	—	18
5	—	14	10	—	9	15	—	4			

Eaſter may be computed from the Epact by the two following Canons.

* *To find Eaſter Limit, or the Day of the Paſchal Full Moon, from* March *the 1ſt incluſive.*

Add ſix to the Epact, reject 3 times 10,
What's left take from 50, the Limit you gain :
Which if 50, one leſs you muſt make it, and even
When 49 too, if Prime's more than 11 †.

EXAMPLE

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*† When the Epact is 0, the next full Moon after March the 21ſt, will happen on April the 13th, to which add

Example *for* 1766.

Epact=18
18+6=24
50—24=26=Limit.

$$\begin{array}{r} \text{Epact}=18 \\ \underline{6} \\ 24 \\ \underline{50} \\ 26=\text{Limit.} \end{array}$$

By the Limit, and Dominical Letter to find Eaſter Day.

If the Letter and 4 from the Limit you take,
And What's left from next Number which
Sevens will make;
Adding then to the Limit what laſt does
remain,
You the Days from St. David's to Eaſter
obtain †.

Example

---

add 31 for the Days in March, and the Sum 44 is the Limit. From this Number therefore the Epact is to be ſubſtracted, but only when it is leſs than 24; becauſe the Remainder, or Limit is, never to fall ſhort of 21. When the Epact is more than 24, 30 muſt be added to 44, and it muſt be ſubſtracted from 74. But when it is 24 it muſt be taken from 73, ſince the Limit is never to exceed 49. Likewiſe when the Epact is 25, it muſt be ſubſtracted from 73, if the Golden Number be more than 11, according to the Tables and Directions for placing the Golden Numbers, to point out the Days of the Paſchal full Moons in the new Calendar. Now $\underline{44-\text{Epact}}=50-\text{Epact}+6$ therefore add 6 to the Epact and ſubſtract from 50, which is more convenient in working, and the Rule will hold in all Caſes.

† The Reaſon of this Rule is becauſe D ſtands againſt *March* the 1ſt, which is 4 Letters ſhort of the next A in the

Example *for* 1766.

Limit.=26, Dom. Let. A=1
5+4=9
26—9=17
21—17=4
26+4=30
March 30 Eaſter Day

Limit=26 E=5
9 4
17 9
21=next Sevens.
4
26=Limit.
30 Days.
March 30=Eaſter Day.

The Age or Change of the Moon may be found, pretty nearly, by the following Canon, in which the 12 Numbers anſwer to the 12 Months, beginning with *January*.

Janus 0, 2, 1, 2, 3, 4, 5 6,
8, 8, 10, 10, theſe to the Epact fix,
The Sum, bate 30, to the Month's Day
add,
Or take from 30, Age or Change is had †.

Example.

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the Calendar; therefore if you take 4 from the Limit, and alſo the Number of the Letters from A to the Dominical Letter of the Year incluſive, you come to a *Sunday*, from whence therefore the Days to *Eaſter Sunday* conſiſt of Sevens, or intire Weeks; Conſequently if you ſubſtract what now remains of the Limit, from the next higher Number which is made up of Sevens, the Remainder is the Number of Days from the Paſchal full Moon to the next *Sunday* after it: *That* therefore, added to the Limit, gives the whole Number of Days from *March* the 1ſt to *Eaſter* incluſive.

† The Reaſon of adding theſe Numbers to the *Epact* in the ſeveral Months, is becauſe the *Lunar Synodical Months*

Example March 10, 1766.

18+1+10=29=Moon's Age.
18+1=19
30−19=11=Day of the Change.

Ep.=18
1=N°. of the Month.
19
10=Day of the Month.
29 Days=Moon's Age.
30
19
11 March=Change.

Months fall ſhort of the *Calendar Months*; ſo that the *Epact*, which expreſſes how much the Lunar Year falls ſhort of the Solar or Calendar Year, muſt be conſidered as continually increaſing; and therefore to find the new Moons which are the Beginnings of the *Synodical Months*, an Addition muſt be made to the Epact in every Month, and more and more as the Year advances; which additional Numbers are called the *Menſtrual Epacts*. Only nothing is to be added to the Epact in *January*, becauſe the *annual Epact*, together with the Day of the Month, does then expreſs the true Age of the Moon: But as *January* has 31 Days, which is near 2 Days more than a Synodical Month, therefore the Beginning of the Lunar Month in *February*, will fall near 2 Days ſooner than it did in *January:* Conſequently 2 is the *Menſtrual Epact* of *February*; and then as *February* has but 28 or at moſt 29 Days, which may be accounted one Day leſs than a *Synodical Month*, the next Lunar Month will begin one Day later in *March* than it did in *February*; Conſequently the *Menſtrual Epact* of *March* decreaſes inſtead of increaſing, and is but 1. If from thence you reckon the Lunar Months to conſiſt of 30 Days and 29 interchangeably, the new Moons will fall ſo much earlier in the following Months, than the new Moon did in *January*, as is expreſſed by the *Menſtrual Epacts* in the Canon, *viz.* 2 Days in *April*, 3 in *May*, &c. until they amount to 11 Days at the End of the Year, which are then added to the *annual Epact*.

* *To find the Time of the Moon's coming to the South, and of High-Water at* London Bridge.

Four times the Moon's Age, if by 5 you
divide,
Gives the Hour of her Southing: Add 2 for
the Tide †.

EXAMPLE, Moon's Age=9 Days,

Moon's Age=9×4=36
36÷5=7 remains 1
Southing=7 Hours 12 Minutes.
7+2=9
High-Water at 9 H. 12 M. p. m.

```
        9
        4
      5)36(7 H.
        1
     12 M=1/5 H.
   7 H. 12 M. p. m.=Southing.
   2
   9  12=High-Water.
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*† The Reaſon of this Rule is, that as the Moon at the Change comes to the South with the Sun, or at 12 o'Clock; and as there are 30 Days, nearly, from one new Moon to another, and 24 Hours in a Day; therefore ſhe loſes one Day with another $\frac{24}{30}$ or $\frac{4}{5}$ of an Hour in the time of her Southing: Now the Moon's Age, or Number of Days from the Change being multiplied by 4, the Product is ſo many *fifths* of an Hour as ſhe has loſt, which divided by 5 is reduced to *Hours*, and the Remainder, if any, multiplied by 12 will be Minutes.

The Reaſon of adding 2 Hours to the Time of the Moon's Southing, for High-Water at London Bridge, is becauſe, though it is High-Water in the open Sea, under the Meridian of London, when the Moon is on that Meridian, yet the Tide takes about 2 Hours more in flowing up to London.

CHAP.

CHAP. V.

Of EPOCHAS *or* ÆRAS.

AN Epocha or Æra is a fixed Point of Time, at or near to which ſome remarkable Event has happened, from whence a Series of Years is computed, as, from the *Creation of the World*, from the *Deluge*, from the *Birth of Chriſt*, &c.

As the Conſtitution of Epochas is merely arbitrary, and not founded on any aſtronomical Conſiderations, different Nations have made Uſe of different Epochas, commonly taken from ſome remarkable Occurrence in their reſpective Hiſtories. Thus the *Romans* computed their Years from the Building of *Rome*. The *Greeks* from the firſt Inſtitution of the *Olympic Games*, which were celebrated at the Beginning of every fifth Year. Hence they computed their Years by *Olympiads*, each Olympiad containing four Years. The *Turks* and *Arabians*, and generally all that profeſs the Mahometan Religion, uſe the Epocha of the *Hegeira*, which is computed from the Time of *Mahomet*'s Flight from *Mecca* to *Medina*.

The ancient *Jews* made Uſe of various Epochas, taken from remarkable Occurrences in their Hiſtory, as from their *Exodus* or Departure from *Egypt*, from the Building of *Solomon's Temple*, from the *Aſſyrian* and *Babylonian Captivities*, &c. The modern *Jews* uſe, principally, the Epocha of the *Creation*. The Epocha of *Chriſt*, or *A. D. i. e.* the Year of our Lord commencing from our Saviour's Nativity, is now chiefly uſed by Chriſtians, at leaſt throughout *Europe*; for the *Abyſſinian* Chriſtians are ſaid to uſe the *Diocleſian Æra*, in all their Eccleſiaſtical Computations; which is otherwiſe called the *Æra of the Martyrs*, becauſe of the great Number of Chriſtians that ſuffered Martyrdom in the Reign of the Emperor *Diocleſian*. The vulgar Chriſtian Æra, whoſe Author was *Dionyſius Exiguus*, an Abbot of *Rome*, in the ſixth Century, is allowed by the beſt Chronologers to begin four Years too late, or after the true Time of Chriſt's Birth: Yet long Uſe has now ſo eſtabliſhed it, that there is leſs Inconvenience in uſing it with that Error, than there would be in correcting it. *Dionyſius* dated his Æra from the Conception of Chriſt, which he ſuppoſed to be on *March* 25*th*, which Method obtained in *England* until the Year 1752. But now the firſt of *January* is reckoned the Beginning of the

Year in all the *Britiſh* Dominions, as well as by moſt other Nations of *Europe*.

Beſides theſe great Epochas, as we may call them, it has been uſual to compute by leſſer Epochas, commencing with the Beginning of the Reign of Emperors and Kings, and expiring at their Death. Thus the ancient *Romans* reckoned by the Years of the Reign of their Emperors; and thus in *England* the *Anno Regni*, which is computed from the Beginning of the King's Reign, is generally uſed in Acts of Parliament, and Law Inſtruments.

A TABLE *of ſome of the more conſiderable* Epochas *which are uſed in ſacred and profane Hiſtory, reduced to the Years of the* Chriſtian Æra, *and the* Julian *Period.*

	Years before Chriſt.	Julian Period.
The Creation of the World	4004	711
The Deluge —— ——	2348	2367
The *Exodus* —— —	1498	3216
Founding of *Solomon*'s Temple	1018	3697
Firſt Olympiad —— ——	776	3938
U. C. or building of *Rome*	735	3961
Æra of *Nabonaſſar*, much uſed by Aſtronomers	747	3967
The *Aſſyrian* Captivity of *Iſrael*	724	3990
The *Babylonian* Captivity of *Judah* — —	601	4113
Death of *Alexander* the Great	324	4390
Birth of Chriſt, or Chriſtian *Æra* —— —— —	*A.D.*	4714
Deſtruction of *Jeruſalem*	69	4783
Æra of *Diocleſian*, or of the Martyrs — — —	284	4997
Hegeira of the Mahometans	622	5335
Beginning of the Reformation	1517	6230
Acceſſion of King *George* III.	1760	6473

AN

APPENDIX,

Attempting to explain the Account of the firſt and fourth Day's Work of Creation, in the firſt Chapter of *Geneſis.*

THE Difficulties with which the Moſaic Account of the Creation ſeems to be preſſed are chiefly theſe two:

FIRST, That the Earth is ſaid to be enlightened, and the Succeſſion of Day and Night ſettled the firſt Day; and yet the Sun (whoſe Light makes Day to the Earth) not created until the fourth Day.

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SECONDLY, That God ſhould take five Days in making this Earth, and its Furniture, and yet but one Day, *viz.* the fourth, in creating the Sun, Moon, and Stars, (in Compariſon with all which, this Earth is but a mere Point or Atom) may ſeem very unlikely; for though it be not impoſſible to Divine Power, it ſeems hardly reconcileable to Divine Wiſdom: and this Account of the Creation appears ſtrangely irregular, and the ſeveral Parts of it out of all Meaſure diſproportionate to one another.

In order to ſolve theſe Difficulties, let it be obſerved,

1. That the Moſaic Account of the Creation does not ſeem to be deſigned for an Account of the whole Creation of God; for there is no mention of the Creation of Angels in it *: and beſides, the firſt Verſe, *In the Beginning God created the Heaven*

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* If by the *Morning Stars which ſang together, when God laid the Foundation of the Earth,* Job xxxviii. 4, 7. we are to underſtand Angels, according to the common received Opinion, which ſeems very probable, from their being called the Sons of God in the Words that follow, *and all the Sons of God ſhouted for Joy*; that Text gives a plain Intimation that Angels were in being at the very Beginning of the Creation of this World; *or when God laid the Foundations of the Earth*; and therefore that they were created before it. And does not the Alluſion in that Text, *viz.* the Angels being called, or compared to Stars, at that Time, ſeem further to intimate, that there were Stars alſo then in Being, and conſequently that there were Stars created before this World; or, however, before the fourth Day?

and the Earth, which may be conſidered as the Title, or general Contents of the whole following Account, does expreſsly limit it to the mundane Creation, even the *Heaven* and the *Earth*. And by the Heaven, in this Chapter, is meant nothing but the *Firmament*, or Air, which ſupports the Clouds, as appears from Verſes 7, and 8, *God made the Firmament, and divided the Waters which were under the Firmament from the Waters which were above the Firmament, and he called the Firmament HEAVEN.* The Moſaic Account of the Creation ſeems plainly therefore to be a deſigned Account of the Creation of this Planet only, *viz.* the Earth and its Atmoſphere, with its various Furniture: the Sun, and many, at leaſt, of the Stars being, it may be, created before. Though it is not unlikely that the Moon, being a conſtant Attendant on the Earth, and deſigned, in a good Meaſure, for the Uſe of it, was created at the ſame Time; and perhaps we ſhall find ſome Reference to her Motion in this Account afterward.

2. If there be any conſiderable Parts of the Work of the Creation of this World, which are not taken Notice of in any of the other Days, and which will fully anſwer the Phænomena of the firſt and fourth Day's Works, it is highly probable thoſe

are the very Works there intended and referred to.

Now it is certain, that God's giving the Earth its diurnal Motion on its own Axis, and its annual Motion in its Orbit round the Sun, (to which we may alſo add his giving the Moon her Motion round the Earth) were very conſiderable Parts of the Work of the Creation of this World, and to which no Reference can be ſuppoſed in the Account of any of the Six Days Work, unleſs in the firſt and fourth.

Let us then ſuppoſe that the firſt Day's Work which *Moſes* deſcribes, was God's giving the Earth its diurnal Motion; and let us enquire how that will anſwer the Phænomena related in verſes 2, 3, 4, 5.

Verſe 2. *And the Earth was without Form and void, and Darkneſs was upon the Face of the Deep, and the Spirit of God moved upon the Face of the Waters.*

Ver. 3. *And God ſaid, Let there be Light: and there was Light.*

Ver. 4. *And God ſaw the Light that it was good: and God divided the Light from the Darkneſs.*

Ver. 5. *And God called the Light Day, and the Darkneſs he called Night: and the Evening and the Morning were the firſt Day.*

The Particulars of this Account are,

1. That *the Earth was without Form and void, i. e.* a mixed and confuſed Maſs of

Solids and Fluids, of Earth and Water, without any ſuch *Form* of Land and Sea, Continents, Iſlands, *&c.* as it afterwards received. And *void*, or deſtitute, of all the Furniture of Trees and Plants, as well as of animal Inhabitants.

2. *And darkneſs was upon the face of the deep*. The Hebrew Word (תהום) *Deep* is elſewhere applied to the very Bottom of the Sea, which is moſt remote from the upper Surface, and out of Sight; as *Job* xxviii. 14. *Exod.* xv. 5. *Iſaiah* lxiii. 13. Suppoſe it ſhould mean here the lower Hemiſphere of the Globe, which was remote from the Sun; (for it ſeems natural to ſpeak of that Hemiſphere which was towards the Sun, and enlightened by his Rays, as the Top, or upper Part; and of the other, as the Bottom, or lower Part:) Then the Meaning would be, that the lower Hemiſphere was as yet all dark, having no Light from the Sun, as the upper had.

Or rather, if Mr. *Whiſton*'s Hypotheſis may be admitted, that *the ancient Chaos, and Origin of our Earth, was the Atmoſphere of a Comet.* (*vide* New Theory of the Earth, *page* 73. *fourth Edition.*) Or, as that moſt penetrating Philoſopher Dr. *Halley* ſeems to ſuſpect, *that it might be a former World, reduced to a Chaos by the Choc of a Comet* (*vide* Philoſ. Tranſ. N° 383. or Mr. *Eames*'s Abridgment, Vol.

VI. Part II. Page 4.) If, I ſay, it may be admitted, according to either of theſe Hypotheſes, or any other, that the Chaos had been created, and was in being, ſome conſiderable Time before the Six Days Work begun, by which it was formed into a habitable World; we may then underſtand the Word (תהום) *Deep*, in this Text, in the more common ſcriptural Senſe of it, *viz.* as ſignifying a great Sea of Water, or vaſt fluid Body. For ſuppoſing the Chaos to be a thick muddy Fluid, conſiſting of Earth and Water mixed together, and ſuppoſing it had no diurnal Motion before the Six Days Work begun; one Hemiſphere would probably be, in a good Meaſure, dried and cruſted by the Heat of the Sun continually ſhining on it; while the other, which was conſtantly in Darkneſs, and deſtitute both of the Light and Heat of the Sun, would be all fluid, or a vaſt muddy Sea. And this is what, perhaps, we are to underſtand by the *Deep* and the *Waters* in this Text.

3. *And the Spirit of God moved upon the Face of the Waters.* The Hebrew Word (מרחפת) *moved*, is ſaid, by moſt Expoſitors, to refer to Incubation; or to a Hen's ſitting upon, and hatching her Eggs, and brooding her Young. But this ſeems to be ſaid, without ſufficient Reaſon; for the ſame Word is uſed but in two other Places in all

the Bible, and there does not appear to be any Reference to Incubation in either of them. One is *Jerem.* xxxiii. 9. where it is rendered in the Engliſh *ſhake*, and fitly enough, as appears by the Context, *My Heart is broken within me, all my Bones ſhake*. The other is *Deut.* xxxii. 11. where it is rendered to *flutter*. *As an Eagle ſtirreth up her Neſt, fluttereth over her Young, ſpreadeth abroad her Wings, taketh them, beareth them on her Wings.* But neither is there any Reference, in that Place, to Incubation, or Brooding. For the young Eagles are there ſuppoſed to be already hatched and ſufficiently brooded, ſo as to be fit to fly abroad. The Parent Eagle is now teaching them to fly; in order to which, after ſhe has ſtirred them up, or awakened them, ſhe flies backward and forward over the Neſt, in their Sight, in order to induce them to imitate her; and when ſhe has at length prevailed with them to ſpring up into the Air, ſhe bares them up with her Wings, when they are in Danger of falling. So Eagles are ſaid to do when they are teaching their young ones to fly *. So that this Word imports no more than to *move*, or, at moſt, to *move ſwiftly*. The Senſe then may very well be, that the Spirit of God moved the

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* Vid. *Nature Diſplayed*, Vol. I. Part II. Page 63.

Surface of the Globe, and thereby gave it its diurnal Motion *.

Mr. *Whiſton* ſays, in his *New Theory of the Earth*, Page 111, "Dr. *Halley* and "myſelf do find, from the Phænomena "of the Variation and Inclination of Needles, that the external Parts of the Earth "received the original Impulſe which cauſed "the diurnal Motion, and that it was from "them conveyed to the internal Parts." If ſo, *the Spirit of God moving upon the Face of the Waters*, or making the Surface to move, is a very juſt and philoſophical Account of God's giving the Earth its diurnal Motion.

4. *And God ſaid, Let there be Light: and there was Light. God ſaid* is a Sort of Poetical Phraſe, intimating how ſuddenly, and with what Eaſe, this Motion was communicated to ſo great a Body by the Divine Power; like *Pſalm* xxxiii. 9. *He ſpake and it was done, he commanded and it ſtood faſt.* Thus God willed that the whole

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* מְרַחֶפֶת from רָחַף commoveri. Part. Præſ. Pihel. Verba quæ in Kal ſunt neutra in Pihel activa ſunt, ut לָמַד didicit לִמֵּד diſcere fecit docuit, *Buxtorf. Theſ.* Therefore מרחפת ſignifies *made to move*, or *put in Motion*. Then the exact Engliſh of רוּחַ אֱלֹהִים מְרַחֶפֶת עַל־פְּנֵי הַמָּיִם is, *the Spirit of God made the Face*, or Surface, *of the Waters to move*, or communicated Motion to it, according to the Uſe of the Particle עַל, *Gen.* xxxviii. 12. *Judg.* ix. 49. 1 *Sam.* i. 10. &c.

Globe ſhould be enlightened; and no ſooner was it *willed*, but it was *effected*, by the Spirit of God's moving upon the Face of the Waters, or making the Surface of the Globe to move; and Day-light was hereby diſtributed ſucceſſively to all Parts of the World.

5. *And God ſaw the Light, that it was good: and God divided the Light from the Darkneſs. And God called the Light Day, and the Darkneſs he called Night: and the Evening and the Morning were the firſt Day.* Thus was God's will of enlightening the Earth completely executed; and hereupon Light and Darkneſs were equally divided to the whole Globe, and the Regular Succeſſion of Day and Night was ſettled and eſtabliſhed. Mr. *Whiſton* indeed ſuppoſes, in his *New Theory of the Earth*, p. 85. that the Earth's diurnal Rotation did not commence till after the Fall of Man. But may not the preſent Shape of the Earth be objected to that Hypotheſis, *viz.* That it is an oblate Sphæroid, having its Diameter at the Equator above thirty Miles longer than its Axis; which has undoubtedly been occaſioned by its diurnal Rotation. For the ſame Mr. *Whiſton* obſerves in his *Aſtro. Prin. of Religion*, p. 32. that "all Globes, which have no diurnal Re-"volutions about their own Axis, muſt, "by the Equality of the Weight of Bo-

"dies in all their Regions, be perfect "Spheres; and all the Parts of their Sur"face muſt, generally ſpeaking, be at the "ſame Diſtance from the Center. But "all Globes that have ſuch a diurnal Ro"tation, (which will neceſſarily be ſwifteſt "at the Equator, and, by Conſequence, "will cauſe the Parts to recede from the "Axis of Motion, chiefly near the Equa"tor) will be oblate Sphæroids, or higher "in the Equatorial, and lower in the Po"lar Regions."

Now if the Earth were at firſt a perfect Sphere, and the diurnal Rotation were given to it after it was finiſhed; then either,

1. Such an Alteration of the Shape of the whole Globe, after it was finiſhed (as the diurnal Rotation is ſuppoſed to occaſion) muſt bring a prodigious Confuſion upon the whole Surface, and throw it into a ſort of Chaos again. Or,

2. If only the fluid Parts, or the Water, would yield to the centrifugal Force, and be thereby thrown into an oblate ſphæroidical Form, but not the ſolid Parts, or Land; then the Waters, by their being raiſed ſo much higher than the Land near the Equator, would overflow the Land, and bring a laſting Deluge on thoſe Parts of the Earth: and, on the other Hand, the Wa-

ters would be ſunk in the Polar Regions many Miles below the Land.

Is it not therefore more probable, that the Globe received its diurnal Motion on the firſt Day of the Creation; while the Earth and Water continued in one mixed Maſs, and before they were ſeparated from each other?

And is it not alſo probable, that God's giving the Earth its diurnal Motion was the very Work, deſcribed by *Moſes*, of the firſt Day?

If it ſhould be objected, that, according to this Hypotheſis, it might as well have been ſaid, *God ſaid, Let there be Darkneſs*, as *Let there be Light*; ſince, by the diurnal Rotation, Darkneſs and Light were equally divided throughout the whole Globe; it may be replied,

1. That *Light* and the *Day*, being ſo much more pleaſant and uſeful than *Darkneſs*, and the *Night*, (though that alſo has its great Uſe,) it was more natural to ſpeak of the Light, as being now diffuſed over the whole Globe, than of Darkneſs. And it is a more beautiful and elegant Account of this Day's Work, to deſcribe it by the Production of Light, than of Darkneſs; though both of them were now made to ſucceed in their Turns to one another.

2. It is moſt natural to underſtand the Word *Light*, ver. 3. (*God ſaid, Let there be*

be Light) in juſt the ſame Extent as the Word *Darkneſs* in the Verſe before, to which it is oppoſed. (*Darkneſs was upon the Face of the Deep.*) Now if the *Deep*, the Face of which was in Darkneſs, means only one Hemiſphere, then the new Production of *Light* muſt be underſtood in Reference only to one and the ſame Hemiſphere. And it is obſervable that the Scene of that Action, by which we ſuppoſe the new Light was produced, is repreſented to be *the Face of the Waters*, meaning, probably, the ſame as the *Deep* or the dark fluid Hemiſphere; not but that the Force which gave the Globe its Rotation might be communicated to the whole Surface: but as the *Waters*, or the *Deep* only was deſtitute of Light before, and upon that Hemiſphere only was new Light now produced, *that* is with peculiar propriety mentioned as the Scene of this Action. As for the *Earth*, or drier Hemiſphere, though it *was without Form and void*, yet it enjoyed the Light of the Sun before; but *Darkneſs was upon the Face of the Deep*, therefore *the Spirit of God moved upon the Face of the Waters*; upon which that Hemiſphere was enlightened, as well as the other, and Day and Night were equally divided to all Parts of the Globe.

Let us again ſuppoſe, that the Fourth Day's Work was God's giving the Earth its annual Motion round the Sun, and the Moon its Motion round the Earth; and let us ſee how theſe two Motions will anſwer the Phænomena deſcribed in Verſes 14, 15, 16, 17, 18, 19.

Ver. 14. *And God ſaid, Let there be lights in the firmament of the heaven, to divide the day from the night; and let them be for ſigns, and for ſeaſons, and for days, and years.*

Ver. 15. *And let them be for lights in the firmament of the heaven, to give light upon the earth.*

Ver. 16. *And God made two great lights; the greater light to rule the day, and the leſſer light to rule the night:* he made *the ſtars alſo.*

Ver. 17. *And God ſet them in the firmament of the heaven, to give light upon the earth.*

Ver. 18. *And to rule over the day, and over the night, and to divide the light from the darkneſs: and God ſaw that it was good.*

Ver. 19. *And the evening and the morning were the fourth day.*

The Particulars in this Account are as follow:

Let there be lights in the firmament of the heaven, to divide, &c. or, (as the Hebrew יהי מארת ברקיע חשמים להבדיל may as well be rendered) *let the lights in the firmament of the heaven be to divide*, &c. importing not their firſt being created on that Day, but their being made to ſerve new Purpoſes; to which they were now applied and adapted, by Means of the Earth's and Moon's Motions in their reſpective Orbits. As

1. *To divide the day from the night*, which indeed had been effected by the former Motion that was given to the Earth on the firſt Day. But as now the Sun and the Moon were made to ſerve all their deſigned Uſes and Purpoſes to the Earth, it was no inelegant Repetition to recite them here all together, this, as well as the others. They were now made, not only to divide the Day from the Night, but alſo

2. *To be for ſigns, and for ſeaſons, and for days, and years.*

(1.) *For Signs*, ſuch as the Changes and various Phaſes of the Moon, and the ſolar and lunar Eclipſes; which are ſo many ſenſible Signs, or Indications, to Men, of the Divine Wiſdom, Power, and Goodneſs. Thus the *heavens declare the glory of God; and the firmament ſheweth his handy-work. Pſal.* xix. 1. Or, *for Marks of Diſtinction*, (as the Hebrew Word אות ſignifies, *Gen.* iv. 15. *God ſet a mark upon Cain*,) *i. e.* betwixt one Part and Portion of Time and another; to which Purpoſes the Changes of the Moon, the Equinoxes, Solſtices, *&c.* are greatly uſeful.

(2.) *For Seaſons*, to produce a Change and Variety of Seaſons; as Spring, Summer, Autumn, and Winter.

(3.) *For Days*, either to make a Difference in the Length of Days; or to diſtinguiſh remarkable Days, for ſolemn Feſtivals, (ſuch as the firſt Day of the Year, and the firſt Day of the lunar Month, which were obſerved by the Jews;) and for many other Conveniencies in civil Life to all Nations.

(4.) *And Years*, *viz.* to meaſure Time by Years, and Cycles of Years, which is of vaſt Uſe to Men in the Computation of Time, and in keeping Records of human Affairs.

All which Uſes of the Sun and Moon to the Earth, depend upon and reſult from the Motions of the Earth and Moon in their reſpective Orbits.

3. *To be for lights in the firmament of the heaven, to give light upon the earth. In the firmament*, *viz.* as their apparent Place; for though our Reaſon informs us of the remoter Diſtances of the Heavenly Bodies; yet, to our Eyes, (which are not able to diſtinguiſh any Difference in the Diſtance of viſible Objects, beyond the Limits of a few Miles,) they all appear as

if they were really in the Firmament, or Earth's Atmoſphere; which is therefore the proper Place to repreſent them in, as they are ſeen from the Earth.

Both the Sun and the Moon were now made *to be for lights, to give light upon the earth*; which it is very poſſible the Moon might not do before, being placed, perhaps, in Conjunction with the Sun till the fourth Day. Nor did the Sun before enlighten the Earth in the ſame Manner as now, when the Earth had received its new Motion. Or, perhaps, this 15th Verſe is only a Repetition, like Verſes 17th and 18th, which ſee below.

4. *And God made two great lights, the greater light to rule the day, &c.* Ver. 16. The Hebrew Word for *made* in this Text is not (ברא) *Bara*, as in Ver. 1. which more generally ſignifies to create, or bring into Being; generally, I ſay, for even this Word *Bara* is ſometimes applied to extraordinary Divine Operations, in which there is yet no new Creation, or Production of any new Being. Thus it is uſed concerning God's *making* the Earth to open and ſwallow up *Korah* and his Company. *Numb.* xvi. 30. See alſo *Exod.* xxiv. 10. *Iſa.* xlv. 7, 8. *Pſal.* li. 10. Therefore there is no abſolute Neceſſity of taking the firſt Production of the Chaos, into the Account which *Moſes* gives, in this Chapter,

ter, of the Creation of the World: That might have been in being long before any Part of the Work which is here deſcribed was begun. Or, if the firſt Verſe ſhould refer to the Production of the Chaos, yet I can ſee no manner of Neceſſity of underſtanding Ver. 16. of a new and proper Creation of the heavenly Lights; for here the Word for *made* is עשה *haſah*, a Word of very general Meaning, which is uſually applied to any Sort of Operation and Action; and, particularly, it ſignifies to *conſtitute*, *order*, or *appoint*, as God (*haſah*) *made Moſes and Aaron*, when he appointed them to their reſpective Offices in the State and Church of *Iſrael*, 1 *Sam.* xii. 6. The ſame word is applied to the making Men Prieſts, 1 *Kings* xii. 31, 2 *Chron.* xiii. 9. The Meaning of it ſeems to be diſtinguiſhed from *creating*, *Gen.* ii. 3. *God reſted from all his works which he had created and made*; which, perhaps, may be thus underſtood: Which he had not only brought into Being, but diſpoſed them into Order. Thus, on the fourth Day, God *made* the two great Lights, (which we ſuppoſe to have been created before,) as he now made them to ſerve new and different Purpoſes from what they had done before; juſt as the Princes of *Iſrael* are ſaid to have *made the houſe of* Jonathan *the* *priſon*, or *they made it for a priſon-houſe*, (אתו עשו לבית הכלא) *Jer.* xxxvii. 15. when they converted it to that Uſe. So here, *God made the two great Lights*; that is, he made them *to rule*, even *the greater of them*, *viz.* the Sun, *to rule the day*, by lengthening ſome Days, ſhortening others, and by diſpenſing a greater Quantity of Light and Heat to ſome Days than to others. *And the leſſer light*, *viz.* the Moon, *to rule the night*, by making ſome Nights light, and leaving others dark; enlightening only Part of ſome Nights, ſometimes the former Part, and ſometimes the latter.

As for *the Stars*, mentioned at the End of Ver. 16. let it be obſerved, that the Words *he made*, which are immediately prefixed to *the Stars*, in our Tranſlation, are not in the Original. (Which, indeed, our Tranſlators have intimated, by printing them in a different Character.) Suppoſe then we connect *the ſtars* with *night*, the Senſe will be, *he made the leſſer light to rule the night and the ſtars* *. Thus while the Moon is performing her periodical Courſe, and ſeems to traverſe among the Stars, ſhe vails from our View, ſometimes one Parcel of Stars, ſometimes another, by her Body and her Light, to a conſiderable Diſtance from her; which, perhaps, may be intended here by her *ruling the Stars.*

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* לממשלת הלילה ואת הכוכבים *ad dominum noctis et ſtellarum.* Thus את is the Sign of the Genitive Caſe, *Numb.* x. 2. למסע את המחנות *ad profectionem Caſtrorum, Numb.* xxiii. 10. מספר את רבע ישראל *numerum quartæ partis* Iſrael.

Or if we ſhould follow the more common Verſions, and connect *the Stars* which *God made* in the Beginning of the Verſe; the Meaning may then be, that, by giving the Earth its new Motion, on this fourth Day, *he made the Stars alſo*, as well as the Moon, *to rule the Night:* Which Senſe is rendered very probable by comparing *Pſal.* cxxxvi. 7, 8, 9. *To him that made great lights——the ſun to rule the day——the moon and ſtars to rule by night.* And now the Stars were made to rule the Night in another Manner than they would have done if the Earth had only had its diurnal Motion; for then the ſame Hemiſphere of Stars muſt always have appeared (in a clear Sky) at the ſame Hour of every Night, at the ſame Place; whereas, by Means of the Earth's annual Motion, the fixed Stars are diſpoſed into a regular Succeſſion of Appearance, through the ſeveral Seaſons of the Year; and hereby ſome Nights are illuminated with a more glorious Hemiſphere of Stars than others are. We may add alſo, that hereby the *ſtars are made to rule over the ſeaſons of the year*, which may, poſſibly, come into the Senſe of the Text; for it was a uſual Thing with the Ancients, to diſtinguiſh the different Seaſons of the

Year, by the Stars which riſe and appear at thoſe Seaſons. Thus in *Job* xxxviii. 31, 32. we read of *the Seaſon of Mazzaroth*; and of *the ſweet Influences of Pleiades*, meaning, I ſuppoſe, the Spring Seaſon, when that Conſtellation riſes and appears above the Horizon; and alſo of *the Bands of Orion*, by which I underſtand the Winter Seaſon, when the Earth and Waters are often bound up, as it were, by the Froſt. But whether by thoſe two Hebrew Names, *Chimah* and *Cheſil*, were meant both the ſame Conſtellations, which we now call *Pleiades* and *Orion*, may admit of a Doubt. However, it is certain, that the ſucceſſive appearing of the fixed Stars, ſome at one Seaſon of the Year, and ſome at another, is occaſioned by that Motion of the Earth, which our Hypotheſis ſuppoſes it received on the fourth Day.

Ver. 17th and 18th are nothing but a Repetition of what was ſaid before, ſuch as is very common in the Hebrew Writings; and of which ſort a Multitude of Inſtances might be readily produced from the ſeveral Books of the Old Teſtament.

Thus will the Motions of the Earth and Moon, in their proper Orbits, completely anſwer all the Phænomena of the fourth Day's Work of Creation; and we eaſily perceive how God, by giving the Earth and the Moon their orbicular Motions on that Day, made the two great Lights, *viz.* the Sun and Moon, to ſerve all the Purpoſes which are there mentioned. Probably, therefore, that was the very Work of the fourth Day.

This Hypotheſis perfectly reconciles the Moſaic Account of the Creation with true Philoſophy; and without putting any harſh or unnatural Senſe on any of the Words and Phraſes.

If it ſhould be objected, that the true Motions of the Earth and Moon, which we ſuppoſe are referred to in this Account of the Creation, were not known ſo early as *Moſes*'s Time, nor till ſeveral Ages after; it may be ſufficient to anſwer, That *Moſes* wrote this Account by Inſpiration of the Spirit of God, who was perfectly acquainted with theſe Things: And it does not follow, that becauſe *Moſes* wrote it, he therefore underſtood it himſelf; for the Prophets did not always underſtand the meaning of their own Propheſies; as appears from 1 *Pet.* i. 11. *The Prophets—— ſearching what, or what manner of Time the Spirit of Chriſt which was in them did ſignify*, &c.

One cannot ſure ſuppoſe, that this Account of the Creation was deſigned to teach the *Iſraelites* (who were a poor labouring People, but lately come from working at the Brick-kilns) ſuch deep Points of Philoſophy,

loſophy, as the true Motions of the Earth and Moon; but rather it was deſigned to teach them to reverence the great Creator of all Things; and alſo to preſerve them from the Idolatry of the Heathen Nations around them, who worſhipped the Sun and Moon, and other Creatures which God had made. But yet, as this Account was wrote by Inſpiration, we muſt ſuppoſe it is all agreeable to Truth, and to the Nature of Things. And the Skill of the Divine Author is in this truly admirable, that the Account of the Creation is here given, for the Uſe of the People, in ſuch Words and Phraſes as were ſuited to the Vulgar Conceptions; and yet it is at the ſame Time perfectly conſiſtent with true Philoſophy.

Upon the Whole then, according to this Hypotheſis, it may appear that the firſt Chapter of *Geneſis*, inſtead of meriting that Contempt which ſome Men have caſt upon it, deſerves rather to be eſteemed, not only as the moſt antient, but as the moſt truly philoſophical and beautiful Account of the Creation, that ever was publiſhed in the World.

AN
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TO
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